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Stratigraphy of the Beekmantown Group in Southeastern Pennsylvania

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Stratigraphy of the Beekmantown Group in Southeastern Pennsylvania

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3

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

LIST OF ILLUSTRATIONS

FIGURES

FIGURES

FIGURES

PLATES

PLATES

TABLES

STRATIGRAPHY OF THE BEEKMANTOWN GROUP IN SOUTHEASTERN PENNSYLVANIA

by John P. Hobson, Jr.*

ABSTRACT

The Beekmantown Group in Berks County, Pennsylvania, has been found to be readily divisible into four formations named in ascending order; Stonehenge Formation, Rickenbach Formation, Epler Formation, and Ontelaunee Formation. The Stonehenge consists mostly of limestone with some interbedded dolomite in the lower part. The Rickenbach and Ontelaunee Formations consist essentially of dolomite with interbedded chert and some limestone. The Epler Formation is made up of interbedded limestone and dolomite. Eight members are defined within the formations. Seven rock types and 28 rock subtypes in the Beekmantown of central Berks County are described in detail and their probable genesis discussed. An addition to existing paleontological data of the Beekmantown carbonates east of the Susquehanna River is provided by identification, tentative in parts, of two genera of trilobites, three genera of brachiopods, four genera of gastropods, and one cephalopod genus.

Correlation and comparison of local sections in the respective formations and integration of the results with published data have enabled establishment of a two-dimensional stratigraphic framework striking in a general southwest-northeast direction along the Great Valley. The Beekmantown is shown to thicken in a southwestward direction from the Delaware River; the thickening is accompanied by a gradual increase in the ratio of limestone to dolomite. The lateral relations of the Beekmantown formations, including the Rockdale Run Formation of eastern Franklin County, appear to be gradational and to be normal changes in lithofacies. The Stonehenge and Epler Formations thicken southwestward, whereas the Rickenbach and Ontelaunee Formations thin in the same direction. The Ontelaunee Formation changes from esesntially dolomite in central Berks County to interbedded dolomite and limestone in Lebanon and Dauphin Counties to the southwest. The working hypothesis is presented on the basis of stratigraphic interpretations that the Ontelaunee Formation in Dauphin, Lebanon, and Berks Counties is in part Middle Ordovician in age.

Relations of the Beekmantown Group to the overlying rocks between the Schuylkill and Susquehanna Rivers have been restudied in the light of new information. The writer agrees with those workers who believe that one major unconformity exists in these rocks in the area. A new genetic interpretation of the relations is given.

Integration of paleontologic and petrologic data with the stratigraphic framework has revealed the existence of three lithofacies types and eight lithofacies subtypes in the Beekmantown and their geographic distribution and cyclic occurrence.

Changes in lithofacies and thickness of the Beekmantown in the Great Valley of Pennsylvania appear to have been controlled primarily by basin tectonics.

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INTRODUCTION

Background and Purpose

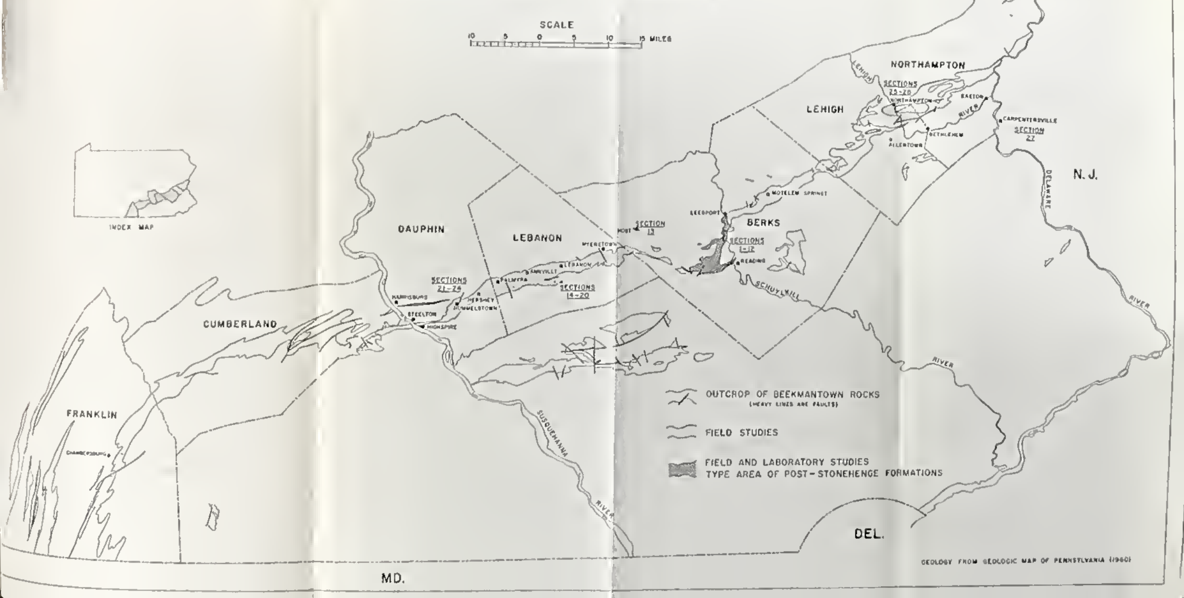
Rocks mapped as Beekmantown on the Geologic Map of Pennsylvania (Gray and others, 1960) are exposed in somewhat discontinuous belts throughout the Great Valley from the Maryland border northeastward into New Jersey.

Recognition of Beekmantown strata in the Great Valley of Pennsylvania apparently dates from the discovery of Lower Ordovician fossils in southern Pennsylvania by G. W. Stose (1908) and in the vicinity of the Lehigh River by B. L. Miller (1911). With the exception of a preliminary report on the Beekmantown of Berks County (Gray, 1951) only brief references had been made to the character and succession of the Beekmantown rocks in the Great Valley east of the Susquehanna River prior to this study (Miller, B. L., 1911, 1925, 1939, 1944; Stose and Jonas, 1922, 1927; Miller, R. L., 1937; Gray, 1952a, 1952b; Gray and others, 1954; Willard, 1955). Earlier work on these rocks in the Lehigh River and Delaware River areas, before their designation as Beekmantown, has been summarized recently by Willard (1958). Published paleontological data from Beekmantown rocks is in Prime (1883), Lesley (1889), Ulrich (1911), and Miller (1911, 1939, 1941). Miller listed four species and two genera in his report of 1911 and an additional four species and four genera in his reports of 1939 and 1941. The nature of lithofacies changes in the Beekmantown throughout the Great Valley was unknown.

The present study was undertaken with the objectives of contributing to existing stratigraphic and petrologic knowledge of Beekmantown rocks and to an understanding of Beekmantown sedimentation and tectonics in southeastern Pennsylvania. Part of the results of this study, concerning the stratigraphy and lithology of the Beekmantown in central Berks County, was presented in an earlier paper (Hobson, 1957), in which the Beekmantown was raised to group status in Berks County and was subdivided into four formations of which three were newly named. The formations were shown to be divisible into members.

The present paper is a detailed description of the local and regional stratigraphic relations of the Beekmantown in the Great Valley of Pennsylvania and of the petrology and paleontology of the Berks County sections. The paper is a revision of the dissertation submitted to the Graduate School of the Pennsylvania State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Hobson, 1958).

FIGURE I AREA OF INVESTIGATION



Area of Investigation

Rock characters have been studied in detail and succession of rock bodies established in the relatively unmetamorphosed rocks of central Berks County, including parts of the Reading and Wernersville quadrangles.

By means of correlated measured sections and published data the Beekmantown rock succession in central Berks County is related to the Beekmantown of Dauphin and Lebanon Counties west of Berks County and to that of Lehigh River and Delaware River areas east of Berks County. The Beekmantown strata east of the Susquehanna River are tentatively correlated with the rock succession as described by Sando (1958) near Chambersburg, eastern Franklin County, Pennsylvania.

Figure 1 shows the principal localities of field study in the area of investigation.

Acknowledgments

This study was supervised at the Pennsylvania State University by Dr. Frank M. Swartz to whom the writer is especially indebted for guidance during the study and in preparation of the dissertation. Other members of the faculty, notably Dr. Robert Scholten and Dr. Richard P. Nickelsen, and members of the graduate school helped, by their discussions, to resolve a number of problems. Dr. Carlyle Gray and Mr. Alan Geyer, of the Pennsylvania Geological Survey, made available to the author much information from their files and experience, and this, along with the time and effort they offered, is sincerely appreciated. Dr. William J. Sando of the United States Geological Survey read the paleontology section and offered invaluable criticism. The author wishes to acknowledge the many contributions made by his wife, Donna, to the completion of this paper.

Financial support for the study has been supplied by the College of Mineral Industries of the Pennsylvania State University, the American Association of Petroleum Geologists, the Pennsylvania Geological Survey, and Whiterock Quarries, Inc. The writer thanks these organizations for their generous assistance.

STRATIGRAPHY OF THE BEEKMANTOWN GROUP IN CENTRAL BERKS COUNTY

Introduction

The first use of the name Beekmantown in Berks County apparently was made by B. L. Miller (1925). The formation appeared on the old Geologic Map of Pennsylvania (Stose and Ljungstedt, 1932). Gray (1951, 1952a, 1952b) has reported chemical data, general rock characters, and succession for

parts of the Beekmantown in Berks County, and indicated the probability that the Beekmantown in Berks County could be subdivided. In the present study the Beekmantown has been found to be divisible into four mappable formations including, at the base, the Stonehenge Formation (Stose, 1908), overlain in ascending stratigraphic order by the recently named Rickenbach Formation, Epler Formation, and Ontelaunee Formation (Hobson, 1957). Accordingly, the name Beekmantown in central Berks County has been raised to the rank of group. The formations were mapped through Central Berks County as part of the study. This information has been included in the new Geologic Map of Pennsylvania (Gray and others, 1960.)

The following discussion is concerned with the field characters of the formations in central Berks County. Detailed petrography of the rock types, detailed measured sections, and a glossary of terms are included in the Appendix. Figure 2 gives an explanation for all symbols used in columnar sections throughout the text.

Figure 3 shows the locations of the principal sections in central Berks County.

Stonehenge Formation

Definition and General Rock Character

Stonehenge limestone and dolomite (Stose, 1908) underlie dolomite of the Rickenbach Formation and overlie a thick mappable zone of concealment in the Reading quadrangle of central Berks County (Hobson, 1957). The Stonehenge was named by G. W. Stose from exposures near Chambersburg, Franklin County, Pennsylvania. In Berks County the reference section of the Stonehenge is along the northwest bank of the Schuylkill River near the borough of Glenside (Fig. 3, section C; Pl. 1, Fig. 2). In the reference section and the surrounding area the Stonehenge is divided into three members: an upper member composed of medium-gray to medium-light-gray, massive-bedded, algal calcilutite with calcarenite-filled "channels"; a middle member of medium-gray, thin-bedded, siliceous-laminated calcisiltite, calcarenite, and calcirudite, including beds of "edgewise conglomerate" and minor amounts of calcilutite; and a lower member of medium-gray interbedded calcilutite, calcirudite, and laminated dolomite. Figure 4 shows, by means of columnar sections, Stonehenge rocks at Glenside, section No. 1, and Wyomissing, section No. 11, (Fig. 3, section A).

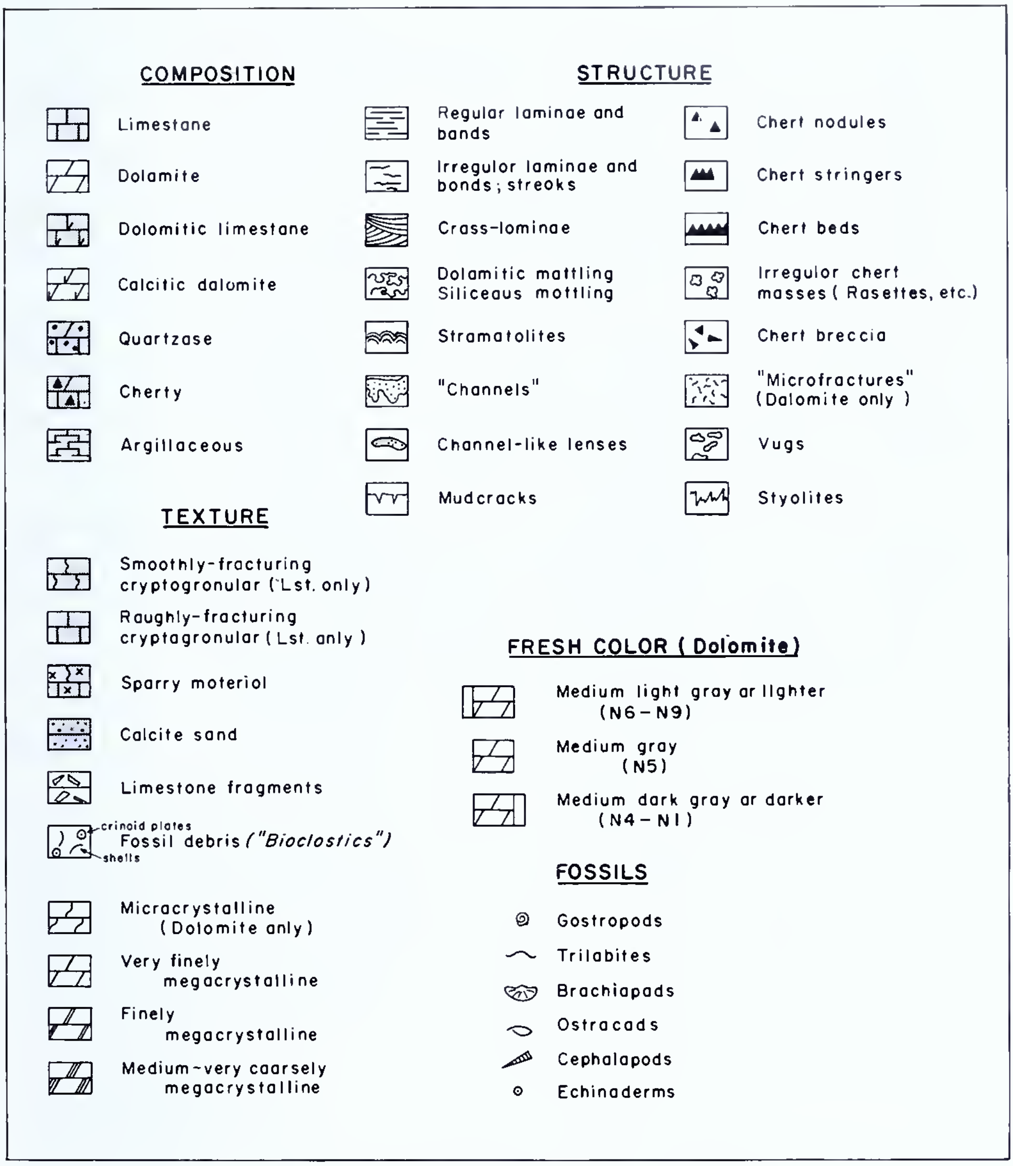
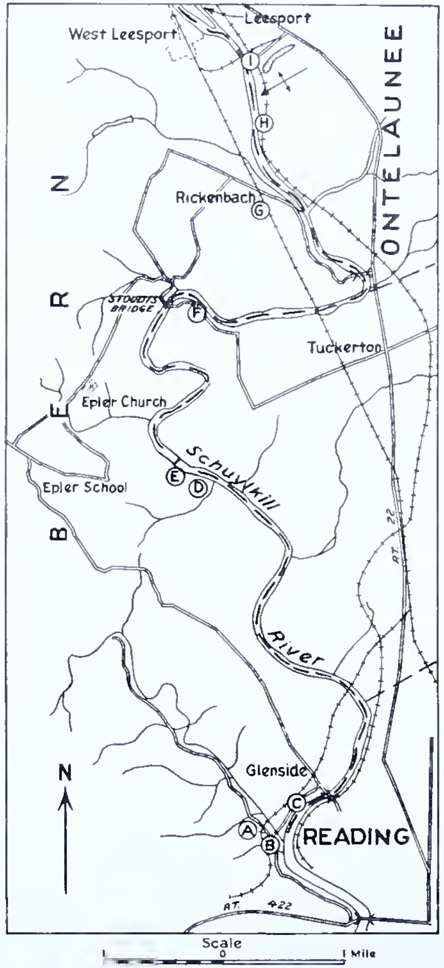


Figure 2. Symbols used for stratigraphic columns.

Contacts

In Southern Pennsylvania (Stose, 1908) and Maryland (Bassler, 1919), the contact between Stonehenge limestone and Conococheague limestone has been placed at a lithologic break between relatively pure, fine-grained limestone above (Stonehenge) and arenaceous, conglomeratic limestone below (Conococheague). The contact as described is similar to the relatively sharp lithologic break between the upper and middle members of the Stonehenge as mapped by the writer in the vicinity of Reading, central Berks County. Limestones of



A	Wyomissing	Stonehenge Fm. Section No. 11 (lower part)
B	Wyomissing	Rickenbach-Ontelaunee Fms. Section No. 11 (upper part)
C	Glenside	Stonehenge Fm. (reference section) Section No. 1
D	Epler School	Rickenbach Fm. (type section, upper member) Section No. 3
E	Epler School	Epler Fm. (type section) Section No. 4
F	Reading Boat Club-Stoudt's Bridge	Ontelaunee Fm. Section No's. 7, 8
G	Rickenbach	Rickenbach Fm. (type section, lower member) Section No. 2
H	Leesport	Ontelaunee Fm. (type section) south limb of anticline, Section No. 6.
I	Leesport	Ontelaunee Fm. (upper part) and Jacksonburg Fm., north limb of anticline Section No. 9 (uppermost part)

Figure 3. Location of sections near Schuylkill River, central Berks County.

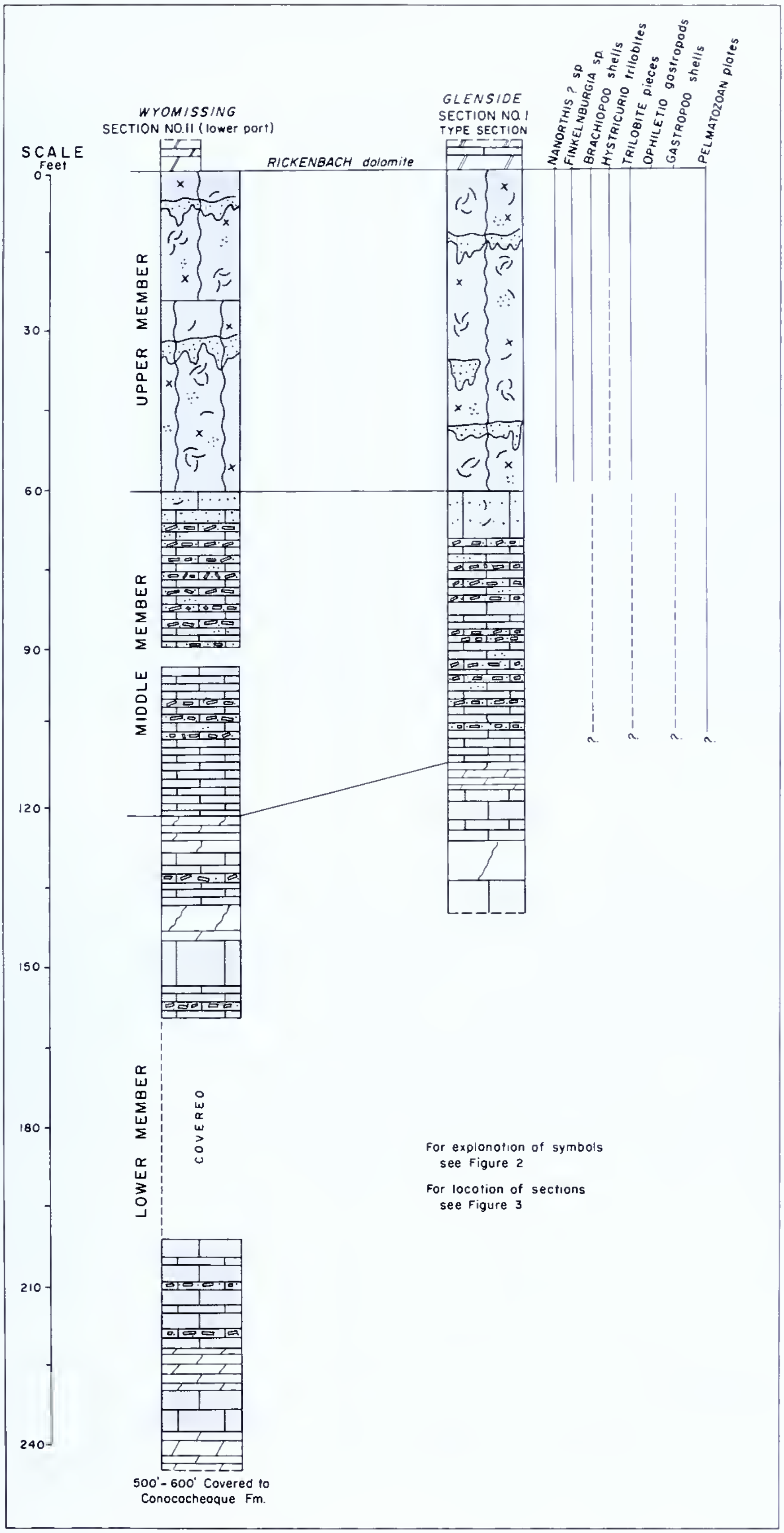


Figure 4. Generalized sections of Stonehenge limestone, central Berks County.

the middle member of the Stonehenge in central Berks County, however, appear to be more similar lithologically and paleontologically to the Beekmantown than to the youngest exposed Conococheague-Elbrook limestones.

An unmetamorphosed section in the uppermost 300 feet of the exposed Conococheague in the vicinity of Reading has been examined in detail. A covered interval with an apparent stratigraphic thickness of 500-600 feet overlies the exposed Conococheague and is persistent throughout central Berks County. Whereas fossil fragments are common in the clastic limestone above the concealed interval they appear to be rare in the underlying exposures. Shaly beds, pink crystalline limestone, quartzose limestone and dolomite, oolite, oolitic chert, and abundant cryptozoon characterize the upper exposure of the Conococheague. These components are not visible in beds overlying the concealed interval and underlying the Rickenbach dolomite. Calcarenite and limestone conglomerate are common in beds overlying and underlying the concealed interval, although closely spaced beds of "edgewise conglomerate" with a pronounced platy character to the fragments appear to be largely confined to limestones above the concealed interval. Where a calcarenitic or conglomeratic texture exists in the Conococheague, megascopically visible quartz grains are invariably present.

On the basis of these observations and the impracticality of subdividing the limestones above the concealed interval and below the Rickenbach, these strata are included in the Beekmantown Stonehenge Formation. For mapping purposes in central Berks County the lower contact of the Stonehenge is arbitrarily drawn at the base of the exposures above the concealed interval.

Recently, Sando (1958) has lowered the Stonehenge-Conococheague boundary in the exposures of the type area in southern Pennsylvania so as to include 200 feet of beds that were previously included in the upper Conococheague. These beds, termed by Sando the Stoufferstown Member of the Stonehenge, appear to be lithologically similar to the middle member of the Stonehenge in central Berks County.

PLATE 1

Figure 1.—Exposure of middle and upper members of the Stonehenge limestone at Wyomissing, Berks County (section No. 11). Dashed line marks contact between members. Massiveness of upper "algal" member contrasts with thin beds of clastic and siliceous-laminated limestone in middle member. Fossiliferous beds in the upper member are exposed along tracks to upper left of photograph. Exposures of lower member are to right of photograph.

Figure 2.—Exposure of middle and upper member of the Stonehenge limestone at Glenside, Berks County (section No. 1). Massive "algal" limestone and thin-bedded clastic limestone are shown in the photographs. Exposures of lower member are to right of photograph. This exposure has been chosen as the reference section for the Stonehenge in Berks County.

PLATE I

Figure 1

Figure 2

The Cambrian-Ordovician boundary in central Berks County cannot be placed at present owing to the inadequately understood paleontology and poor exposure of the stratigraphic units involved. It is possible that the systemic boundary may coincide approximately with the contact between the middle and lower members of the Stonehenge or may fall somewhere in the concealed interval between exposed Stonehenge and Conococheague beds.

The contact zone of the Stonehenge Formation with the overlying Rickenbach Dolomite is poorly exposed at Wyomissing and Glenside. In the Glenside exposures there appear to be incompletely dolomitized limestones interbedded with dolomites near the base of the Rickenbach Formation. At Wyomissing the contact appears to be sharp between massive dolomite above and massive limestone below. Probably the contact relation was at one time essentially transitional but has been obscured by extensive dolomitization of the limestones. In mapping, the top of the Stonehenge was placed between the lowest massive Rickenbach dolomite and the underlying limestones of the Stonehenge. Mapping failed to uncover a well exposed section through the contact zone and the location of the contact can be estimated in the field only with great difficulty.

Distribution and Thickness

The only measurable sections of the Stonehenge Formation in central Berks County are at Glenside and Wyomissing. In these exposures the formation is about 250 feet thick.

Beds of "edgewise conglomerate" along the Schuylkill River north of the mouth of Maiden Creek, if Stonehenge, are the easternmost exposures of the formation seen to date. The formation is not present in exposures near the Lehigh River or the Delaware River in eastern Pennsylvania. The lowermost Beekmantown beds are below the present erosion surface in the western part of Berks County.

The known distribution of Stonehenge Limestone in Berks County is shown on the 1960 Geologic Map of Pennsylvania.

Paleontology

Trilobites, brachiopods, gastropods, and pelmatozoans occur, largely as fragments, in the Stonehenge at Wyomissing and Glenside.

In the upper member the following have been identified in tentative fashion:

BRACHIOPODA
Nanorthis ? sp.
Finkelnburgia ? spp.

TRILOBITA
hystricurid trilobite

The small brachiopod *Nanorthis* ? sp. is especially common, occurring in clusters of closely packed shells, including those of *Finkelnburgia* ? spp.

In the middle member, abundant pelmatozoans as well as rare gastropods, trilobites, and brachiopod fragments have been observed in etched and thin sections. A dolomitized ophiletid gastropod is visible on a bedding plane in the middle member at Glenside.

Some of the fossils are figured in Plate 22.

Correlation of the Lowermost Beekmantown in Berks County with the Stonehenge Formation of Southern Pennsylvania

Fossiliferous beds of the upper and middle members of the lowest exposed formation recognized in the Beekmantown of Berks County during the present study have been correlated with the Stonehenge Limestone (Stose, 1908) of southern Pennsylvania because of: (1) occurrence of limestones of Stonehenge lithology and stratigraphic position in the Carlisle quadrangle (Stose, 1953) and in Lebanon County (Gray and others, 1954) between the type area and Berks County. Since completion of this study, the Stonehenge Formation has been mapped through the entire main belt of Beekmantown rocks from the type area into central Berks County (Gray and others, 1958, 1960; Geyer and others, 1958); (2) evidence in Berks County from fragmentary fossils including specimens of *Nanorthis* ? sp. and *Finkelnburgia* ? spp., a hystricurid trilobite, and an ophiletid gastropod; (3) position in the geologic succession; (4) lithologic similarity; and (5) an essentially transitional relationship in Berks County with overlying strata containing typical Beekmantown fossils.

Rickenbach Formation

Definition and General Rock Character

The term Rickenbach has been proposed for light-gray to medium-dark-gray, thick- and thin-bedded, microcrystalline to coarsely megacrystalline dolomite and interbedded cherts overlying Stonehenge limestone and underlying interbedded limestone and dolomite of the Epler Formation (Hobson, 1957). The formation is named from exposures along the railroad tracks of the Reading Company near the crossing at Rickenbach, Berks County, Pennsylvania (Fig. 3, section G; Pl. 2, Fig. 2). Two members can be recognized in central Berks County. The lower member and lower part of the upper mem-

PLATE 2

Figure 1

Figure 2

ber are exposed at Rickenbach; the upper member is almost completely exposed east of Epler School about two miles south of Rickenbach (Fig. 3, section D; Pl. 2, Fig. 1). Additional exposures south of Leesport (Fig. 3, section H), in Wyomissing (Fig. 3, section B) and in Glenside have been studied.

The lower member of the Rickenbach, generally poorly exposed, is composed of medium gray to medium-dark-gray, finely to coarsely megacrystalline dolomite in massive, generally non-laminated beds. Incompletely dolomitized limestones occur in exposures of the lower member and the tendency of the member to be poorly exposed suggests that these beds may be more common than has been observed. The upper member is well exposed and is made up of light-gray to medium-gray, microcrystalline to finely megacrystalline dolomite with interbedded fine-grained, dark-gray chert and a zone of quartzose beds. Dolomite of the upper member is generally uniformly thin-bedded and laminated.

Columnar sections of the formation are shown in Figure 5.

Contacts

The lower contact of the Rickenbach Formation with Stonehenge limestone, as discussed in a foregoing section, is believed to be essentially transitional although the interpretation is complicated by poor exposure and dolomitization of limestones in the lower Rickenbach.

The contact between the Rickenbach and Epler Formations is well shown in an exposure accessible only by boat, along the southern bank of the Schuylkill River upstream from the Reading Boat Club and east of the former site of Stoudt's Bridge (east of and stratigraphically lower than section F, Fig. 3). In this exposure the relationship between the formations is one of lithologic gradation through interbedded limestone and dolomite. The contact is also exposed south of Leesport in section No. 9 where faults complicate the normal stratigraphic relations in the vicinity of the contact. Although the contact is concealed at the Epler School sections (sections No. 3

PLATE 2.

Figure 1.—Type section of the upper member of Rickenbach Dolomite at Epler School, Berks County (section No. 3). Strata are dipping away from observer. Quartzose dolomites are exposed in foreground. Massive limestones of the lower Epler formation may be seen in middle ground of photograph.

Figure 2.—Type section of the lower member of Rickenbach Dolomite at Rickenbach, Berks County (section No. 2). Strata are dipping steeply toward observer. Beds of Cambrian age are exposed in extensive cut beneath overpass in background. Poor exposure is characteristic of the lower member. Cherty dolomites occurring in transition zone between members are in foreground (see Plate 7, Fig. 3).

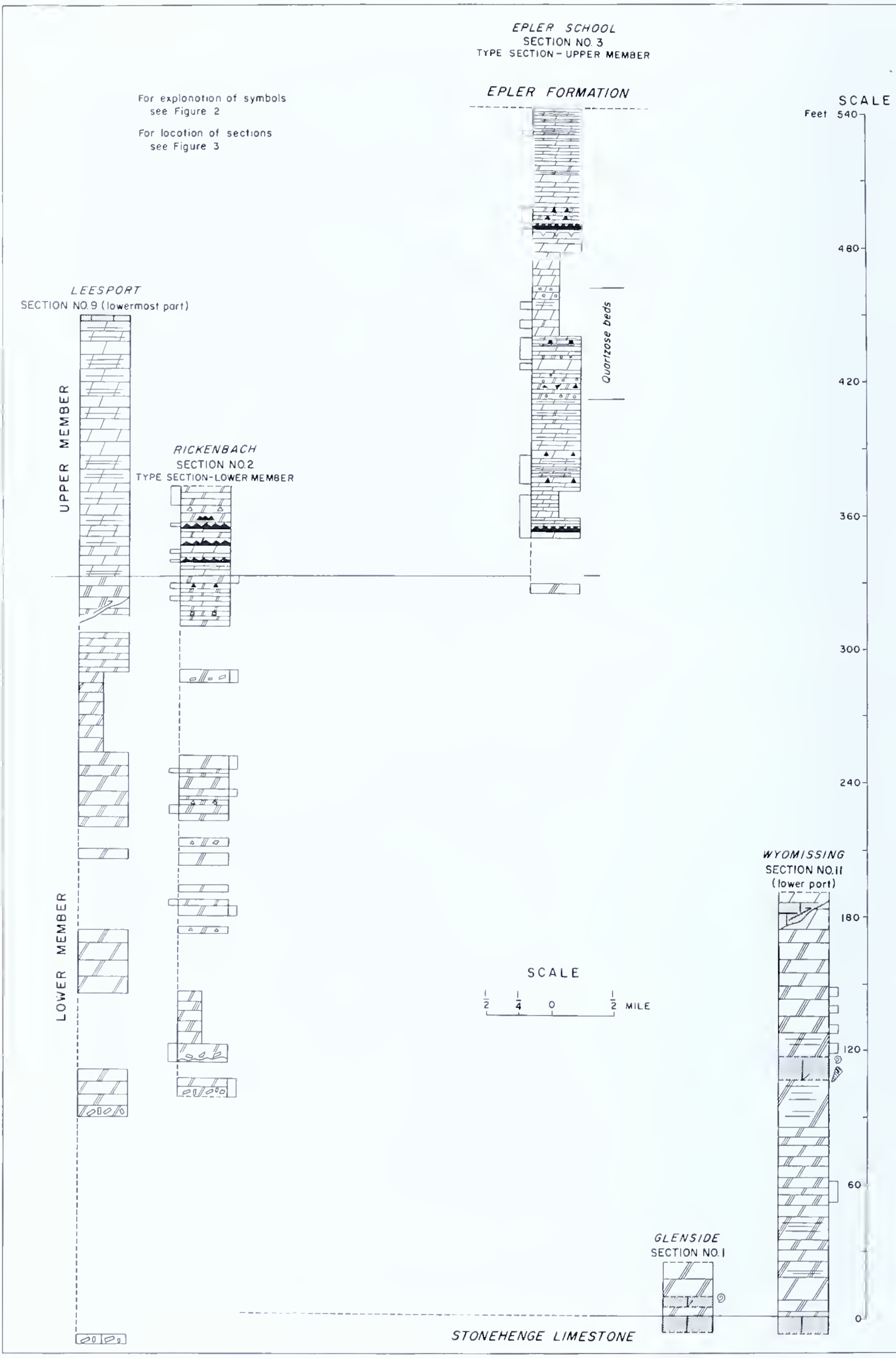


Figure 5. Generalized sections of Rickenbach dolomite, central Berks County.

and No. 4), the increase of bedded dolomite downward in the Epler indicates that the relation between the formations in that area is one of gradation. In Wyomissing the contact is obscured by a fault along which the Epler Formation apparently has moved northwestward against the lower member of the Rickenbach.

Distribution and thickness

In the type section of the formation at Rickenbach, about 225 feet of the lower member is partially exposed above a concealed interval with an apparent stratigraphic thickness of 200 to 250 feet covering the section down to dolomites believed to be in the lower member of the Stonehenge. South of Leesport, section No. 9, 257 feet of the lower member is visible with about 100 apparent stratigraphic feet concealed to beds of flat-pebble conglomerate, probably of the Stonehenge limestone. At Wyomissing 182 feet of the lower member overlies the Stonehenge in a railroad cut. Additional small exposures and float demonstrate the presence of the lower member throughout central and eastern Berks County. From consideration of the above sections and the normal width of outcrop, it appears that the member is about 350 feet thick in central Berks County.

In the reference section of the upper member at Epler School, 188 feet of the upper member is exposed with an apparent stratigraphic thickness of 45 feet separating the member from Epler limestone and about 20 feet concealed to exposures of the lower member. It appears, therefore, that the thickness of the upper member in these exposures in no more than 250 feet. South of Leesport in section No. 9, where complicated by faults, the member is only about 113 feet thick. From consideration of the normal width of outcrop and the apparently uncomplicated section near Epler School, the upper member is about 210 feet thick in central Berks County.

The total thickness of the Rickenbach Formation in central Berks County, therefore, is about 560 feet. The known distribution of the formation is shown on the 1960 Geologic Map of Pennsylvania.

Paleontology

The incompletely replaced limestones in the lower member at Wyomissing contained dolomitized low-spired gastropods and a single orthocerid cephalopod. Structures resembling cryptozoon occur in the upper part of the lower member at Rickenbach.

The upper member of the formation is apparently barren of fossils.

PLATE 3

Figure 1

Figure 2

Epler Formation

Definition and General Rock Character

The term Epler Formation has been proposed for the interbedded limestone and dolomite overlying the Rickenbach Formation and underlying beds referred to as the Ontelaunee Formation (Hobson, 1957). The Epler has been named from excellent exposures along the bank of the Schuylkill River east of Epler School (Fig. 3, section E; Pl. 3, Figs. 1, 2). The formation consists of medium-gray to medium-light-gray limestone with interbedded dolomite. The dolomite, mostly microcrystalline to finely megacrystalline, is unit. The dolomite, mostly microcrystalline to finely megacrystalline, is common throughout, occurring as mottling and in beds. Bedded dolomite is especially common in the lower one-half of the formation and near the contacts with the adjacent formations. Limestones in the lower part are generally of smoothly fracturing cryptogranular texture with large amounts of dolomite mottling, especially at the limestone-dolomite contacts. Limestones of the upper part of the Epler are characterized by large amounts of calcarenite intermixed with limestone pebbles and invertebrate remains.

Figure 6 shows by means of columnar sections the Epler sequence near Epler School and in a small quarry at Rickenbach.

Contacts

The lower contact of the Epler with the Rickenbach Formation has been described in a previous section. The contact is believed to be one of lithologic gradation from the dominantly limestone body of the Epler downward into Rickenbach dolomite.

The contact between the Epler and the overlying Ontelaunee Formation in Central Berks County is placed at the top of the highest limestone bed beneath a prominent zone of chert beds in the Ontelaunee. Although the contact zone is generally poorly exposed, the relationship between the formations appears to be essentially transitional. A transitional relationship is evidenced

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PLATE 3

Figure 1.—Type section of the Epler Formation at Epler School, Berks County (section No. 4). Darker beds are limestone; lighter beds are dolomite. Majority of limestones in this, lower, part of section are fine-grained.

Figure 2.—Type section of the Epler Formation at Epler School, Berks County (section No. 4). Chert beds of lower Ontelaunee Formation are above dam, and abundantly fossiliferous beds of the upper Epler are exposed below dam. With the exception of the Stonehenge, limestone reaches its greatest proportion in the Beekmantown of Berks County in this fossilferous part of the Epler.

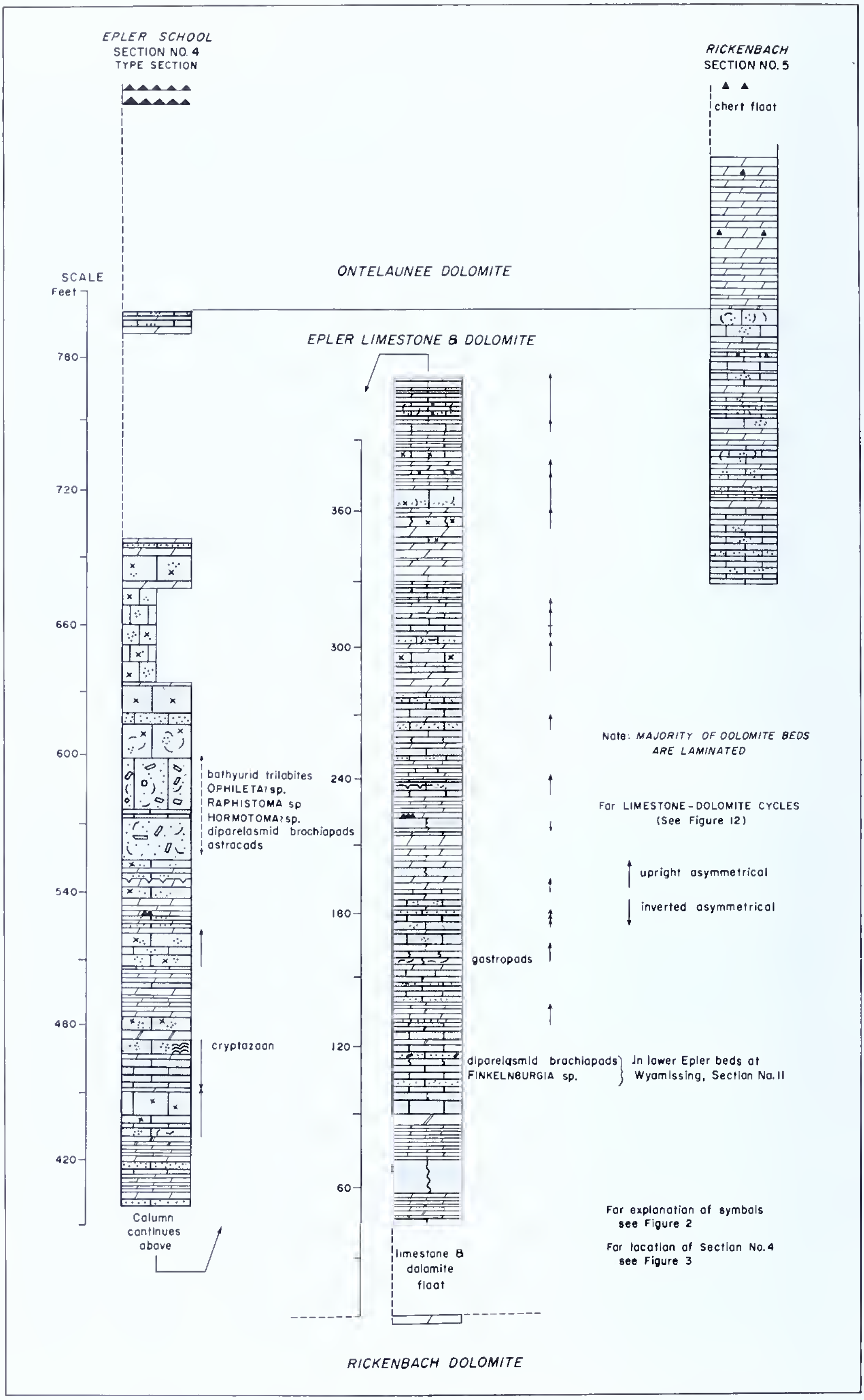


Figure 6. Epler limestone and dolomite at Epler School and at Rickenbach.

by a slight upward increase of bedded dolomite in the Epler near the contact. As in the case of the Stonehenge-Rickenbach contact zone, there appears to be some dolomitization of pre-existing limestone beds in the lowermost Ontelaunee. The line demarcating the contact in central Berks County is placed about 100 feet stratigraphically below the lowest chert bed of the Ontelaunee.

In the vicinity of Host, northeast of Womelsdorf in western Berks County, two quarries expose limestone and dolomite overlain in the western quarry, section No. 13, by Martinsburg shale (Pl. 5, Fig. 2). The limestones, somewhat recrystallized, appear to have been calcarenitic with pebbles and crinoids. They also contain silicious bands and dolomite mottling. Limestones of this type have not been observed above the upper part of the Epler Formation in Berks County. As indicated by Gray (1952b, p. 90) the shale truncates bedding in the carbonates along a surface of apparent unconformity. The writer believes that the unconformity separates beds of upper Epler limestone and dolomite from the Martinsburg and that the entire Ontelaunee Formation is missing.

Distribution and Thickness

The Epler Formation is 798 feet thick in the Epler School section and about 742 feet thick south of Leesport, section No. 9. In the Leesport section faults complicate the usual stratigraphic order. The normal width of outcrop near the Schuylkill River indicates a thickness of about 800 feet for the formation. Near Cacoosing, section No. 12, the formation is apparently somewhat greater than 800 feet thick, although the structural complexity and poor exposure of the beds near Cacoosing make an accurate estimate of thickness difficult in that area.

Paleontology

The Epler is the most fossiliferous unit in the Beekmantown of central Berks County. Fossils are especially common in a 60-foot zone with its base about 250 feet below the top of the formation. The majority of the fossils listed below were identified from this zone in the Epler School section. Small, apparently involute, gastropods are common in some beds of smoothly fracturing cryptogranular limestone in the lower member, but have not been identified. Some of the fossils are shown in Plate 22.

GASTROPODA

The following gastropods have been recognized in the fossil collection. A general absence of ornamentation and whorl cross sections hindered accurate identification in most cases. All are from the 60-foot zone in the upper part of the Epler.

PLATE 4

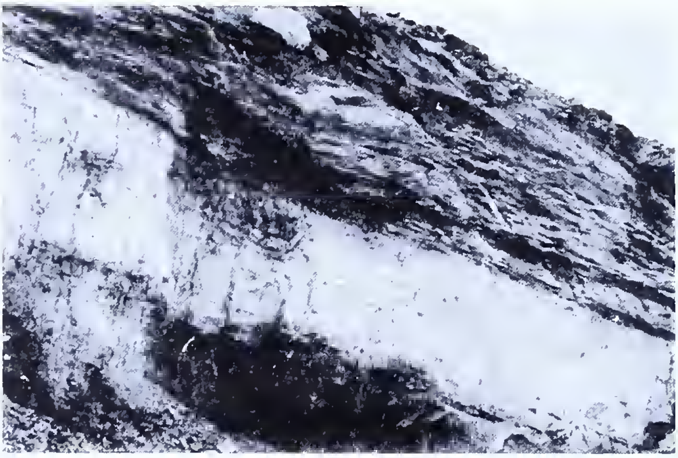


Figure 1

Figure 2

Figure 3

Hormotoma ? sp. *Raphistoma* sp.
Ophileta sp. *Maclurites* ? sp.

TRILOBITA

Trilobites are mostly visible as fairly large, smooth, dark, platy fragments on broken rock surfaces, especially in the upper part of the formation. On the basis of one almost complete cephalon and a fragment of free cheek and genal spine uncovered in the 60-foot zone in the upper part of the formation, the following identification has been made.

Bathyurid trilobite

BRACHIOPODA

Brachiopods appear to be relatively rare in the Epler Formation in central Berks County. Several partially silicified specimens were the basis for the following identification. The specimen of *Finkelnburgia* sp. occurred in the lower part of the formation at Wyomissing, section No. 11. The diparelasmoid brachiopods occur in the upper and lower parts of the Epler.

Finkelnburgia sp.
diparelasmoid brachipods

OSTRACODA

Numerous small, smooth-surfaced, unornamented leperditid ostracod valves have been seen in fragmental limestone in the upper member.

STROMATOLITES

A single bed with cryptozoon occurs in the upper member at Epler School. Siliceous mottles occur in cryptozoon-like structures in the lower member at Epler School.

Ontelaunee Formation

Definition and General Rock Character

The term Ontelaunee Formation has been proposed for the dolomite and interbedded limestone and cherts overlying the Epler Formation and underlying either the Annville Limestone, the Jacksonburg Formation or the Martinsburg Formation in Berks County (Hobson, 1957). The formation is

PLATE 4

Figure 1—Unconformity between Otelaunee dolomite and Martinsburg shale at Wyomissing, Berks County. Foliation in Martinsburg parallels contact and bedding in Ontelaunee.

Figure 2.—Beds of chert and cherty-mottled dolomite in lower member of the Ontelaunee Formation south of Leesport.

Figure 3.—Type section of Ontelaunee Dolomite south of Leesport, Berks County (section No. 6). Beds are well exposed along bank at water level.

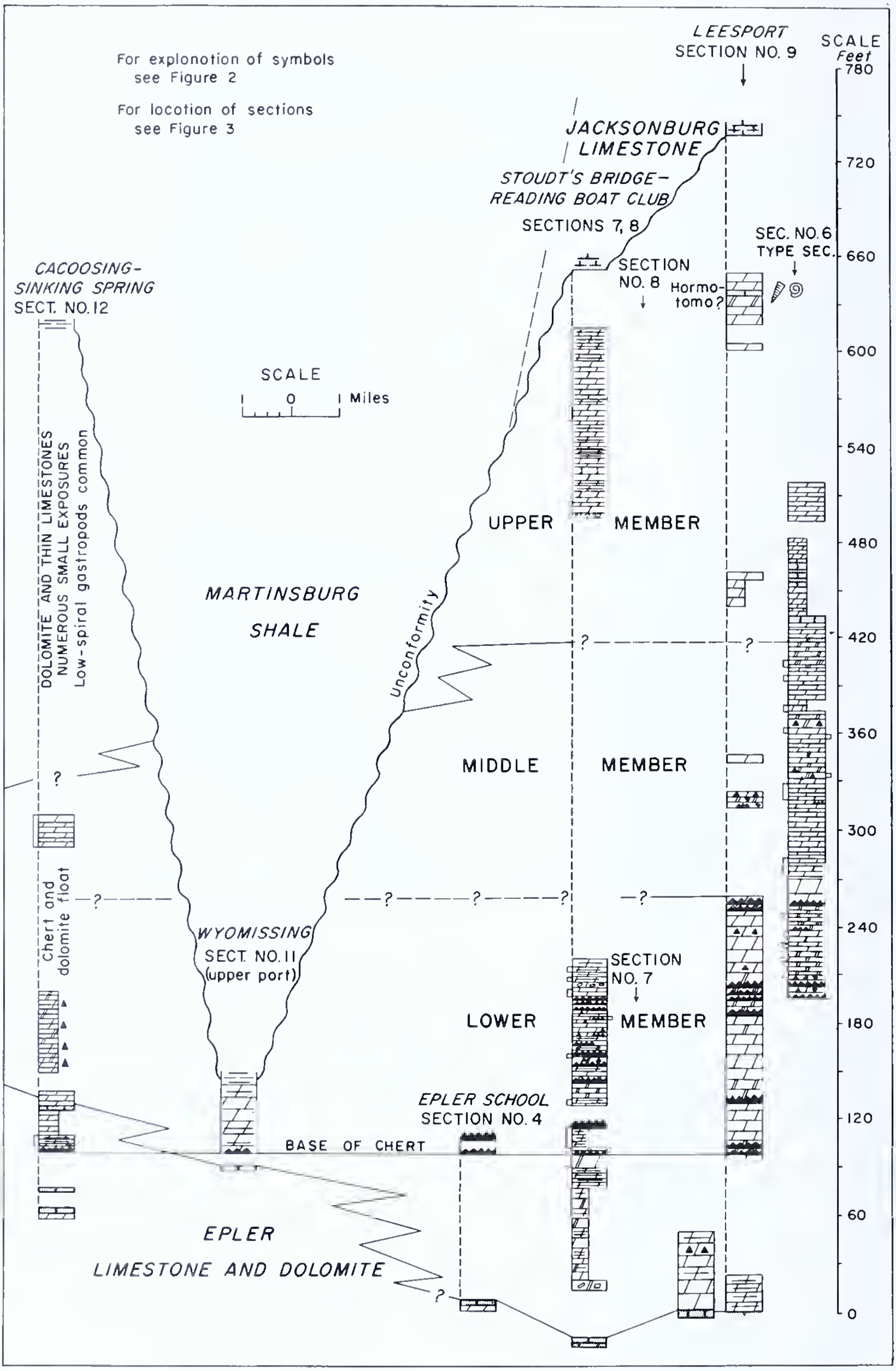


Figure 7. Generalized sections of Ontelaunee dolomite, limestone, and chert, central Berks County.

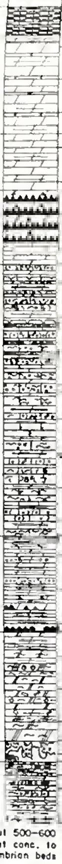
GENERALIZED COMPOSITE COLUMNAR SECTION OF BEEKMANTOWN ROCKS IN BERKS COUNTY

System	Group	Formation	Member	Depth	Description
	Trenton-Black River	Jacksonburg Ls.		50'	Limestone, medium dark gray to dark gray, variable content of argillaceous material; two yellowish weathering bentonites.
					UNCONFORMITY
LOWER ORDOVICIAN	BEEKMANTOWN	ONTELAUNEE	UPPER	2300', 2200', 2100'	Dolomite, medium gray to medium light gray, very finely megacrystalline, weathering yellowish; "gash" weathering; thin interbeds of very-finely-megacrystalline to calcilutitic, dolomitic-mottled limestone; numerous small low-spired gastropods, gastropod resembling Hormotoma sp. and nautiloid cephalopods resembling Orthoceras sp. about 100 feet below the contact with Jacksonburg limestone at section No. 9; regular beds.
			MIDDLE	2000', 1900'	Dolomite, medium gray to light gray, very finely megacrystalline with several microcrystalline dolomite beds; indistinct laminae common on a yellowish weathering surface; regular beds.
			LOWER	1800', 1700'	Dolomite, medium gray to medium light gray, very finely megacrystalline; interbeds of medium-dark-gray, medium-megacrystalline dolomite and dark gray, microcrystalline chert; laminae in dolomites common; chert and fragments of laminated dolomite are commonly brecciated; much nodular chert and cherty mottling.
					TRANSITIONAL
		EPLER	UPPER	1600', 1500', 1400', 1300'	Limestone and dolomite; bioclastic pebble calcarenite; silty calcarenite with cross-beds of quartz silt; dark siliceous laminae and mottles common; dolomitic laminae and mottlings characteristic; mudcracks common; about 35% of the exposures composed of very-finely-megacrystalline, laminated dolomite weathering yellowish; fossils are especially abundant in the beds between 250 and 400 feet below the top of the formation; fossils include Ophileta sp., Maclurites sp., Raphistoma sp., Hormotoma sp., bathyurid trilobites.
			LOWER	1200', 1100', 1000', 900'	Limestone and dolomite; limestones for the most part are smoothly- to roughly-fracturing cryptogranular; calcarenite and calcirudite common but mostly as lenses rather than as beds; dolomite laminae and mottles very characteristic; very-finely-megacrystalline, laminated dolomite beds make up about 45% of the exposures and form cycles through layers of mottlings with limestone beds; large numbers of low-spired gastropods in some of the finer-grained limestones; silicified brachiopods resembling Finkelnburgia? sp. and Diparelasma? sp. in lower part of member at Wyomissing, section no. 11.
					TRANSITIONAL
		RICKENBACH	UPPER	800', 700', 600'	Dolomite, medium gray to medium light gray, very finely megacrystalline with several microcrystalline dolomite beds; typically laminated on a yellowish weathering surface; very light-gray- to light-gray-weathering dolomite common; beds of well-rounded quartz sand in 90 feet zone in upper one-half of member; abundant nodules, stringers, and beds of dark-gray chert, especially near base.
					TRANSITIONAL
			LOWER	500', 400'	Dolomite, medium gray to medium dark gray, finely to coarsely megacrystalline; cycles of lighter-colored, finer-grained dolomite and darker-colored, coarser-grained dolomite; chert rosettes and subnodules; few limestone beds.
					TRANSITIONAL(?)
		STONEHENGE	U	300', 200'	Limestone, medium light gray, very finely megacrystalline to calcilutitic; irregular dolomitic laminae; "channels" and lenses of bioclastic calcarenite; brachiopods very common including Finkelnburgia spp., Nanorthis? sp.; trilobites common including hystricurid types.
			M	100'	Limestone, alternating beds of flat-pebble calcirudite, calcisiltite, and calcilutite; siliceous laminae and mottles; at least two beds of gastropods including Ophileta? sp.; rocks similar to those in the upper Epler Formation.
			LOWER	0	Limestone and dolomite; limestones similar to middle member but with less calcirudite and more regular dolomite bands; much very-finely-megacrystalline, laminated dolomite weathering yellowish in beds; mudcracks. ?
		About 500-600 feet conc. to Cambrian beds			

Figure 8. Generalized composite columnar section of Beekmantown rocks in Berks County

named from exposures in Ontelaunee Township along the east bank of the Schuylkill River about one mile southeast of Leesport (Fig. 3, section H; Pl. 4, Figs. 2, 3) The formation is divided into three members in the type area: an upper member of interbedded microcrystalline to finely megacrystalline dolomite and several thin, medium-light-gray, cryptogranular limestones; a middle member of microcrystalline to finely megacrystalline dolomite; and a lower member of interbedded microcrystalline to medium megacrystalline dolomite and fine-grained, dark-colored chert. The dolomite is generally medium-light-gray to medium-gray in all members. The bedded cherts of the lower member are especially distinctive and easily mappable features of the Ontelaunee.

Figure 7 shows by means of columnar sections the characters of the formation and the division of the Ontelaunee into members.

Contacts

The lower contact of the Ontelaunee with the Epler Formation, as discussed in a previous section, is believed to be essentially transitional.

The abrupt lithological change between Ontelaunee dolomite and the overlying Jacksonburg limestone in central Berks County suggests an unconformable contact. The contact relations are best revealed by section No. 9 in the type area of the Ontelaunee south of Leesport. A discussion of the possible age of the uppermost Ontelaunee, where fully developed in central Berks County, is deferred until the regional stratigraphy of the formation has been discussed later in this paper. In section No. 9, the Jacksonburg Formation contains two beds of sticky, soft, yellowish-weathering shale about 40 feet above the contact with the Ontelaunee. These beds appear to be deposits of altered volcanic ash and may be essentially equivalent to those reported by Miller from Jacksonburg beds of Hull and Sherman Fall age in eastern Pennsylvania and New Jersey (Miller, 1937, p. 1715) and in limestones of other areas (Whitcomb, 1932; Rosencrans, 1933; Kay, 1935). Metabentonites also have been reported from the Myerstown Limestone in Dauphin and Lebanon Counties (Prouty, 1959), the uppermost part of which may be of lower Sherman Fall age (Prouty, 1959, p. 18).

Near Moselem Springs, section No. 10, argillaceous limestone identified as Hershey (Jacksonburg) (Prouty, 1959, p. 26) rests on beds tentatively identified as lowermost Ontelaunee dolomite. Prouty believes this contact to be one of disconformity. However, Gray (1951, p. 51) suggests a fault contact. In the section measured by the writer the exact contact was covered.

As shown on the 1960 Geologic Map of Pennsylvania, the Hershey-Myerstown (Jacksonburg) is present on the surface in a patchy distribution. A valuable clue to the reason for the absence of Jacksonburg in the area

PLATE 5

Figure 1

Figure 2

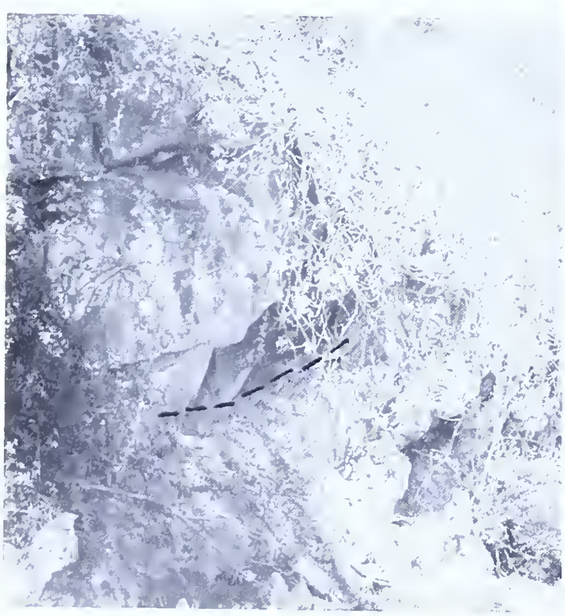


Figure 3

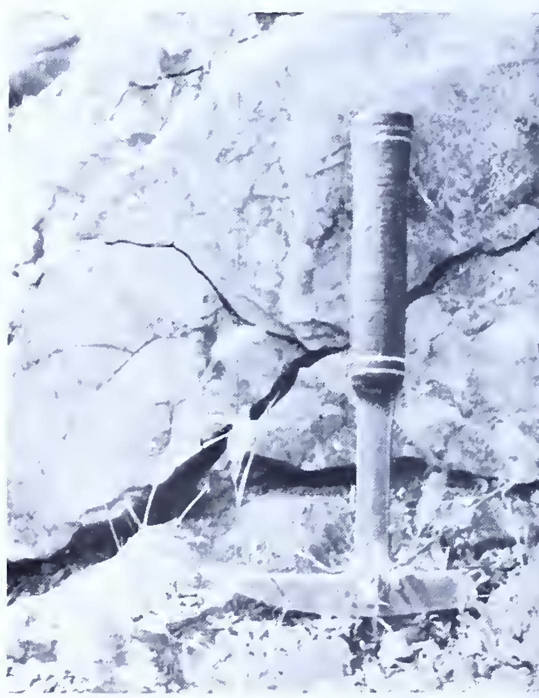


Figure 4

from Route 83 to Wernersville is provided by the outcrops in the Wyomissing, Sinking Spring, and Host areas, section Nos. 11 to 13. At Wyomissing the contact between Martinburg shale and Ontelaunee dolomite. (Pl. 4, Fig. 1; Pl. 5, Figs. 1, 3) is interpreted as an unconformity based upon the following observations: (1) The contact is sharp and slightly undulating; (2) The Jacksonburg Formation is missing; (3) The shale apparently overlies the lower member of the Ontelaunee Formation (Fig. 7) which is estimated to be between 150 and 250 feet thick in the section for the following reasons: Allowing for a stratigraphic loss of 350 to 400 feet along the fault separating the Epler Formation from the lower member of the Rickenbach Formation, the apparent total thickness of the Beekmantown is about 1800 feet, a difference of about 500 feet from the normal thickness in the area. A missing interval of this thickness at the top of the formation would place the contact in the lower member of the Ontlaunee. Cherty dolomites poorly exposed beneath the contact at section No. 11 reenforce this interpretation inasmuch as cherts in the Ontelaunee are especially common in the lower member; and (4) The presence of large, generally angular fragments of dolomite in the basal Hershey and western Berks County (Pl. 5, Fig. 4) indicates nearby erosion. Previous workers (Stose and Jonas, 1927; Gray, 1951, 1952a, 1952b; Prouty, 1959) have noted the absence of the Jacksonburg Formation in this area and have attributed the missing beds, at least in part, to an unconformity. In places, faults separate the Beekmantown and Martinsburg strata as shown on the 1960 Geologic Map of Pennsylvania.

In western Berks County the Annville Limestone, reportedly only 20 feet thick near Womelsdorf (Gray, 1951, p. 3), apparently rests on Ontelaunee dolomite (Gray and others, 1960). The Ontelaunee-Annville contact, better exposed in Lebanon County to the west, will be discussed in the section dealing with regional stratigraphy of the Ontelaunee.

PLATE 5

Figure 1.—Unconformity between Ontelaunee dolomite and Martinsburg shale in the upper part of the Wyomissing section (No. 11). Irregular bed of chert and chert float to right of photograph. Thickness of Beekmantown in the section and occurrence of chert suggest that Martinsburg rests on lower member of Ontlaunee in the exposure.

Figure 2.—Unconformity between Epler limestone and dolomite and the Martinsburg shale in section No. 13 near Host, western Berks County. Shale foliation truncates bedding in the underlying carbonates.

Figure 3.— Overturned contact (fault?) between Martinsburg shale and Beekmantown dolomite at about 1.80 miles west of 75°55′ longitude and 0.55 mile north of 40°20′ latitude in the Reading quadrangle. Float in stream bed near contact contained piece of limestone with *Maclurites magnus*? (see Plate 22, Fig. 11).

Figure 4.—Hershey conglomerate exposed near Womelsdorf, western Berks County. Weathered surface to left of hammer shows angular and subangular fragments of yellowish-weathering dolomite (Ontelaunee?) in a dark-gray matrix of argillaceous limestone.

Distribution and Thickness

As indicated on the 1960 Geologic Map of Pennsylvania, the Ontelaunee belt of outcrop in central Berks County displays a pronounced, somewhat erratic, variation in width. In several places, as south of West Leesport and in the valley west of Cacoosing, the excessive width of outcrop is caused by visible folds. That faults also play a part in the variation of outcrop width is indicated by the large number of exposures with slickensided fault surfaces and shattered beds.

In the type exposures south of Leesport, section No. 6, 320 feet were measured, including the middle member and parts of the lower and upper members. To the north, at section No. 9, the Ontelaunee dips beneath the Jacksonburg Formation. In the line of measurement, section No. 6 is separated from No. 9 by an anticline in the Ontelaunee Dolomite. The outcrop width on the north limb indicates a thickness up to 732 feet for the formation. A thickness of 600 to 700 feet is indicated in sections No. 7 and No. 8 near the former site of Stoudt's Bridge north of Reading. The formation apparently underlies the Jacksonburg Limestone at Stoudt's Bridge as shown on the 1960 Geologic Map of Pennsylvania.

In the vicinity of Wyomissing, section No. 11, the formation, probably represented by the lower member only, is between 150 and 250 feet thick and unconformably underlies the Martinsburg Formation.

Exposures west of Reading in and around Cacoosing and Sinking Spring, section No. 12, point to a thickness for the Ontelaunee probably not exceeding 650 feet in that area where it is in contact with the Martinsburg Formation.

In the vicinity of Host, northwest of Womelsdorf in western Berks County, section No. 13, the entire Ontelaunee Formation is apparently missing between the Epler Formation and the Martinsburg Shale.

East of the Schuylkill River at Moselem Springs, section No. 10, Jacksonburg limestone apparently rests unconformably on or is in fault contact with the lower member of the Ontelaunee.

It appears, from consideration of outcrops and thicknesses in the less structurally complicated areas, that the Ontelaunee Formation is about 675 feet thick where fully developed in central Berks County. In local areas, as at Host, Wyomissing, and Moselem Springs (?) the formation is considerably thinner than normal and, in places, missing entirely. In areas of reduced thickness the Ontelaunee generally directly underlies the Martinsburg Formation.

Paleontology

Fossils have been observed in place in the Ontelaunee only in thin limestones of the upper member. They consist, with the exception of a single orthocerid cephalopod and a high-spired gastropod resembling *Hormotoma,* of low-spired, dolomitized gastropod shells on weathered faces of the limestones. They are usually 1 inch to 2 inches across, consist of 3 to 4 whorls, and appear to be dextrally coiled where viewed above a slightly raised apex.

A piece of limestone in a stream channel near an overturned Martinsburg-Ontelaunee (?) contact in West Reading (Pl. 5, Fig. 3) contained a gastropod in cross section that resembles *Maclurites magnus.* The specimen is figured in Plate 22.

Summary of Rock Character and Rock Succession in the Beekmantown Group of Central Berks County

The generalized columnar section of Figure 8 summarizes the essentials of the Beekmantown rock characters and rock succession in central Berks County near the Schuylkill River.

The succession is divided into four mappable rock bodies; Stonehenge Limestone (Stose, 1908) at the base, overlain in ascending order by the Rickenbach Formation (dolomite), Epler Formation (limestone and dolomite), and Ontelaunee Formation (dolomite) (Hobson, 1957). Two prominent, mappable zones of chert occur, one in the upper member of the Rickenbach and the other in the lower member of the Ontelaunee. Quartzose dolomites are interbedded with the cherts in a unit 109 feet thick in the upper member of the Rickenbach.

The relations between the formations appear to be gradational, although the contacts are not well exposed. The Beekmantown is overlain unconformably by either the Jacksonburg Formation or the Martinsburg Formation in central Berks County. The relation of the Beekmantown and the underlying Conococheague Formation has not been determined with the evidence obtainable at present.

Regional stratigraphic relations of Beekmantown sections through the Great Valley of Pennsylvania are discussed later in this paper.

Fossils are especially common in two parts of the section: the upper member of the Stonehenge and the upper part of the Epler Formation.

PETROLOGY OF THE BEEKMANTOWN GROUP IN CENTRAL BERKS COUNTY

Introduction

The samples from each formation were taken from their stratigraphic order and combined into rock type groups according to composition and texture. Subgroups (subtypes) were based generally on the kinds of sedimentary structures or the apparent absence of structures.

The numbering system used in classifying the rock types and subtypes is based on the Beekmantown samples as a whole and not on those from each formation, i. e. B-la is Beekmantown rock type 1, subtype a. Detailed microscopic descriptions of each rock type are given in numerical order in Appendix 1.

Discussion of the genesis of the rock types is deferred to a succeeding section dealing with the paleogeographic and paleotectonic interpretation of the stratigraphic framework.

Petrology of the Stonehenge Formation

Rock Types and Rock Subtypes

The three members of the Stonehenge as exposed in the sections at Glenside and Wyomissing are composed chiefly of rocks of five types. The rock types and subtypes defined by their most essential characteristics are as follows, in general order of decreasing volumetric importance of the rock types:

Limestone (B-3) smoothly fracturing cryptogranular:
- (B-3c) dolomitic-mottled and silty-argillaceous-laminated
- (B-3d) siliceous-laminated and -mottled

Limestone (B-4) roughly fracturing cryptogranular and very finely megacrystalline:
- (B-4a) silty-laminated and siliceous-laminated and -banded
- (B-4c) dolomitic-laminated and -banded

Dolomite (B-1) very finely megacrystalline:
- (B-1a) apparently structureless
- (B-1b) regularly laminated

Limestone (B-6) calciruditic:
- (B-6a) dolomitic-mottled
- (B-6b) silty-argillaceous-laminated

Limestone (B-5) medium to coarsely megacrystalline (calcarenitic):
- (B-5a) dolomitic-mottled

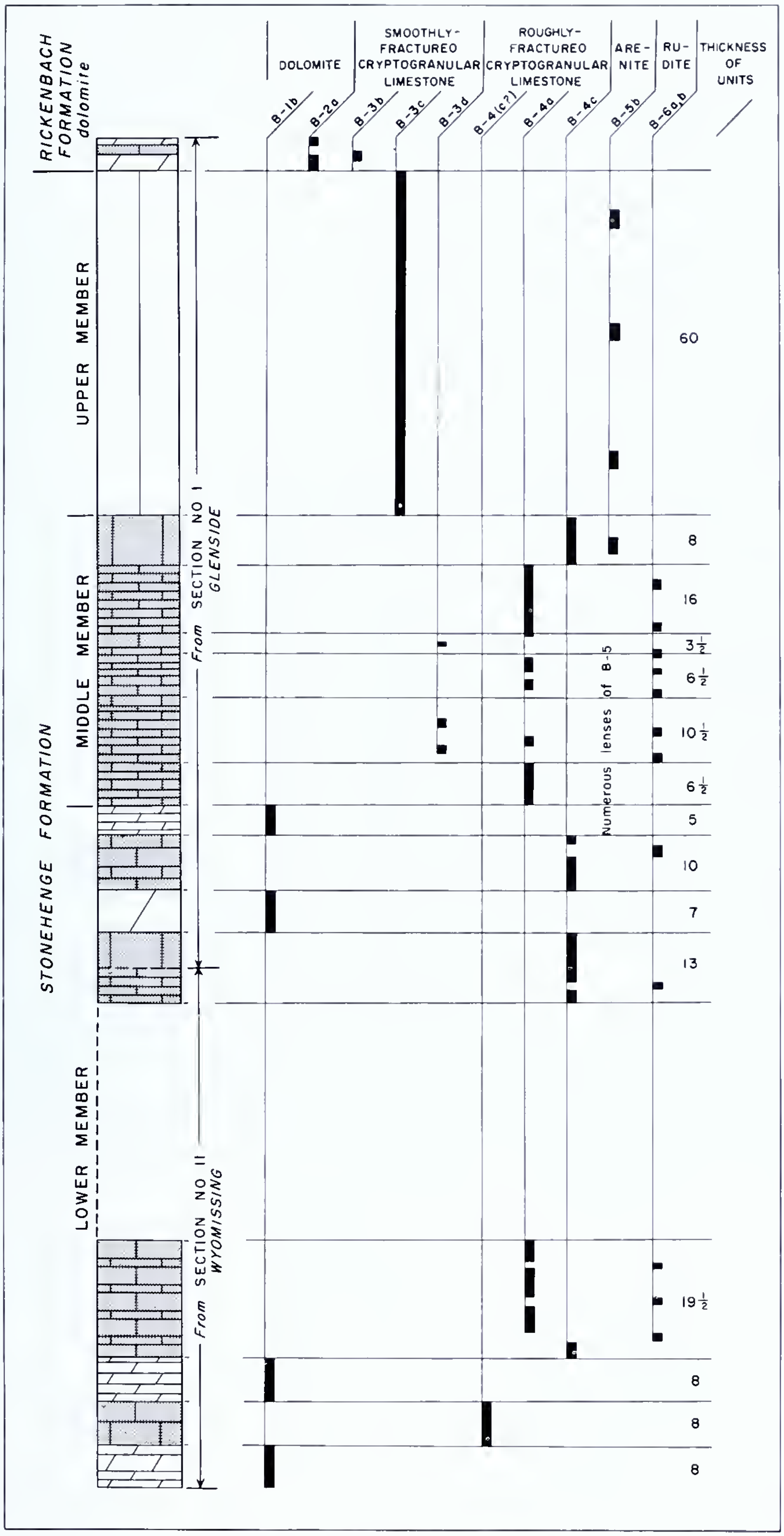


Figure 9.

ribution of rock subtype in a composite section of the Stonehenge Formation at Glenside and Wyomissing.

Table 1

Rock subtypes of the Stonehenge Formation at Glenside and Wyomissing

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
B-1a, B-1b	Dolomite, medium gray (N5), very finely megacrystalline (1/8 to 1/16 mm.), weathering yellowish gray (5Y8/1), lacking apparent sedimentary structures (B-1a) or with regular parallel laminae (B-1b), trace of effervescence with cold dilute HCl; rock bodies are in regular beds.	Subtypes B-1a and B-1b include about 20 percent of the exposed rock in the lower member.
B-3c	Limestone, dolomitic-mottled to silty-argillaceous-laminated, medium light gray (N6), smoothly fracturing cryptogranular to very finely megacrystalline with scattered and clustered sparry calcite crystals, weathering very light gray (N7) to whitish; lenses of fragmental limestone and bioclastics and "floating" bioclastics, with pelmatozoans, brachiopods, and trilobites; irregular silty-argillaceous laminae with variable amounts of dolomite; lobes and lenses of megacrystalline dolomite weathering yellowish gray and with sub-banded appearance in places; mound-like structure and stromatolites are common.	Subtype B-3c includes about 85 percent of the rock in the upper member.
B-3d	Limestone, siliceous-laminated to -mottled, medium gray (N5), smoothly fracturing cryptogranular with clustered sparry calcite crystals, weathering medium light gray (N6); lenses of fragmental limestone and bioclastics; black, anastomosing to reticulate, siliceous laminae and bands weathering into strong relief; rock bodies are in irregular beds.	Subtype B-3d includes about 30 percent of the rock in the middle member and the rock in several beds in the lower member.

Table 1 (cont'd.)

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
B-4a, B-4c	Limestone, silty-laminated and dolomitic- and siliceous-laminated and -banded, medium gray (N5), roughly fracturing cryptogranular to very finely megacrystalline, weathering medium light gray (N6); thin silty-dolomitic laminae, cross-bedded in places; thicker, anastomosing to subreticulate, siliceous laminae and bands (B-4a); yellowish-gray-to yellowish-orange-weathering, wavy laminae and bands (B-4c); rock bodies are in irregular beds.	Subtype B-4a includes about 30 percent of the rock of the middle member and a small portion of that in the lower member; rock of subtype B-4c occurs mostly in the lower part of the middle member and in the lower member.
B-5b	Limestone, dolomitic-mottled, medium gray (N5), medium to coarsely megacrystalline on fresh surface, fragmental limestone with pelmatozoan, brachiopod, and trilobite debris, weathering medium light gray (N6); yellowish-gray-weathering intragranular and patchy intergranular dolomite; silty-argillaceous laminae with variable amounts of dolomite; rock type distributed in irregular channel- and dike-like rock masses transecting bedding in upper member.	Subtype B-5b includes about 15 percent of the rock of the upper member and the rock of several beds in the lower member.
B-6a, B-6b	Limestone, dolomitic-mottled, silty-argillaceous laminated, medium gray (N5), flat-pebble conglomerate with sparry calcite cement, weathering medium light gray (N6) with some whitish weathering pebbles; pebbles variously oriented with respect to bedding; silty-argillaceous laminae (B-6a) with variable proportions of dolomite; patchy intergranular dolomitic mottling (B-6b); rock bodies are in regular beds.	Subtypes B-6a and B-6b include about 15 percent of the rock in the middle member and that of a few beds in the lower member.

The megascopic characteristics of the subtypes are listed more fully in Table 1 and field examples of the rock types are pictured in Plate 6.

Occurrence and Distribution of Rock Subtypes

Lower and Middle Members

The distribution of rock subtypes in the lower and middle members is shown in Figure 9. The lower and middle members of the Stonehenge Formation at Glenside and Wyomissing are composed chiefly of thin, repetitious, and regular layers of smoothly fracturing cryptogranular limestone (B-3d), roughly fracturing cryptogranular limestone (B-4a and B-4c), calcirudite (B-6a and B-6b) and dolomite (B-1a and B-1b). The majority of the middle member is composed subequally of subtypes B-6a, B-6b, and B-4a. Regular beds of subtypes B-1a and B-1b make up about 30 percent of the exposures of the lower member. The limestones of the lower member are generally more fine grained than those of the middle member with B-4c the most common limestone subtype at Glenside.

Upper Member

The upper member is composed of subtypes B-3c and B-5b. As shown in Plate 6, (Figs. 4, 5), calcarenite (B-5b) occurs in channel-like masses enclosed within the massive, poorly stratified rock of subtype B-3c. When viewed perpendicular to bedding, the structures appear as lenses or lobate to finger-like masses cutting the irregular laminae of the enclosing rock.

PLATE 6

Figure 1.—Comparison of rock bodies composed of rock of subtype B-3d below, and B-4a above in the middle member of Stonehenge limestone at Glenside, section No. 1. These bodies form cyclic deposits with bodies of rock type B-6 and subtype B-4c in the middle and lower members of the Stonehenge at Glenside and Wyomissing.

Figure 2.—Beds of flat-pebble calcirudite (B-6) alternate with beds of subtype B-4a and B-3d. Calcite-filled, discontinuous joints and a fault cut bedding. Middle member of Stonehenge Limestone at Glenside, section No. 1.

Figure 3.—Layer of rock of type B-6 showing variable orientation of fragments within a single bed. Middle member of Stonehenge Limestone at Glenside, section No. 1.

Figures 4, 5.—Relations of subtypes B-3c and B-5b in the upper member of Stonehenge Limestone at Glenside, section No. 1. Rock of subtype B-5b occurs as channel-like (C) structures, in places cutting the irregular styolitic stratification of rock of subtype B-3c (A). Styolitic laminae transect the channels in some places. Figure 4 is a view perpendicular to bedding and Figure 5 subparallel to bedding.

Figure 6.—Small fold in rock mostly of subtype B-4a and B-3d in the middle member of Stonehenge Limestone at Glenside, section No. 1. Distortion of the sedimentary structures indicates rock flowage during folding.

PLATE 6

Figure 1

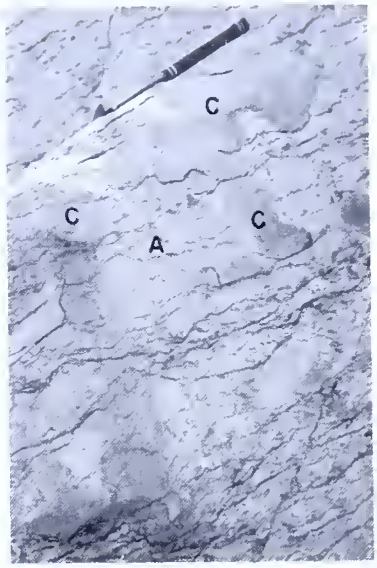


Figure 4

Figure 2

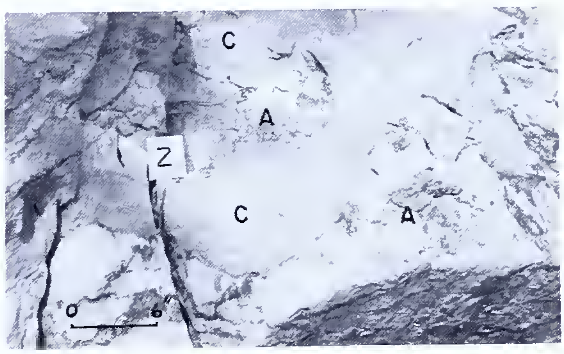


Figure 5

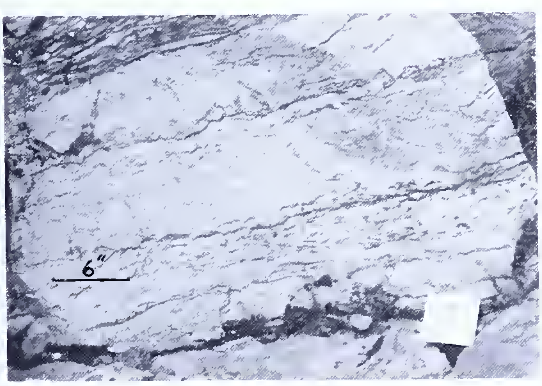


Figure 3

Figure 6

Parallel to bedding the masses appear to anastomose in irregular fashion. A similar relation of these rock types in the Stonehenge of Maryland has been described by Sando (1957, p. 19).

Petrology of the Rickenbach Formation

Rock Types and Rock Subtypes

Lower Member

The lower member, as studied in sections at Rickenbach and West Reading, is composed of rocks of three types. The recognized rock types and subtypes, defined by their most essential characteristics, are as follows, in general order of decreasing volumetric importance:

Dolomite (B-2) medium to coarsely megacrystalline:
- (B-2a) apparently structureless
- (B2e) micro-fractured
- (B-2c) siliceous-mottled and -streaked
- (B-2b) light- and dark-laminated
- (B-2d) paradoloarenitic and paradoloruditic

Dolomite (B-1) finely megacrystalline:
- (B-1b) light- and dark-laminated
- (B-1c) light- and dark-mottled
- (B-1a) apparently structureless
- (B-1f) siliceous-laminated or -mottled
- (B-1i) brecciated

Limestone (B-3) smoothly fracturing cryptogranular:
- (B-3b) dolomitic-mottled

The megascopic characteristics and proportions of rocks of the above subtypes in the lower member of the Rickenbach Formation are listed more fully in Table 2. The generally poorly exposed nature of the member severely limits estimation of proportion of rock types. Examples of the rock types encountered in the lower member are shown in Plate 7.

Upper Member

The upper member as studied in exposure at Epler School, section No. 3, and Rickenbach, section No. 2, is composed of rocks of three types. The rock types and subtypes, defined by their most essential characteristics, are as follows in order of decreasing volumetric importance:

Dolomite (B-1) microcrystalline to finely megacrystalline:
- (B-1b) light- and dark-laminated
- (B-1a) apparently structureless
- (B-1e) light- and dark-mottled
- (B-1g) quartzose
- (B-1f) siliceous-streaked to -mottled

Dolomite (B-2) medium megacrystalline:
- (B-2b) light- and dark-laminated
- (B-2a) apparently structureless

Chert (B-7) dark microcrystalline aggregates occurring in layers

The megascopic characters and proportion of the rock types are listed in greater detail in Table 3. Examples of the rock types studied in the upper member are given in Plate 7.

Summary of Rock Characters

It appears from a megascopic study of the rock types in the Rickenbach that in terms of crystal size the types vary along a series from microcrystalline to coarsely megacrystalline. Furthermore, certain characteristics of composition, color, and structure generally appear to be associated with certain ranges in crystal size. Thin laminae, light colors on the fresh surface, regular bedding, and a yellowish, smoothly weathering surface are characteristic of the microcrystalline and very finely megacrystalline rock types. In contrast, absence of regular thin laminae, darker colors of the fresh and weathered surface, indistinct bedding, and an irregular vuggy-weathering surface typify the medium to coarsely megacrystalline rocks. An appreciable calcitic content also appears to be associated with the coarser lithology. The classification into two major textural groups appears to be applicable to 70 to 75 per cent of the lithologic samples and seems in general to be a natural grouping, emphasizing the relationships and differences between two quite distinct, apparently genetic, types of dolomite. Features of the dolomite and dolomitic limestone rock types as studied microscopically are considered in Appendix 1. Of particular interest are relict textures associated with rock type B-2, the coarser lithology.

Distribution of Rock Types

Figure 10 shows the distribution of the rock subtypes in the Rickenbach Formation as studied at Epler School, Rickenbach, and Wyomissing.

In general, the upper member is composed of medium-gray to medium-light-gray, very finely megacrystalline, laminated dolomite (B-1) with dark chert nodules, stringers, and beds (B-7). Exposures of the lower member

Table 2

Rock subtypes of the lower member, Rickenbach Dolomite at Rickenbach and Wyomissing

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
B-1a, B-1b, B-1e	Dolomite, medium gray (N5) to medium light gray (N6), rarely medium dark gray (N4), finely megacrystalline (1/8 to 1/4 mm.), weathering light gray (N7) to light yellowish gray (5Y8/1), color-laminated (B-1b) and color-mottled (B-1e) or more characteristically lacking apparent sedimentary structures (B-1a); dark chert occurs in nodules and stringers; rock bodies are regularly bedded.	Type B-1 includes 15 percent of the exposed rock in the member, decreasing in proportion toward base.
B-1f	Dolomite, medium gray (N5) to medium dark gray (N4), finely (and medium) megacrystalline, weathering yellowish gray (5Y8/1); darker areas weathering into strong relief as irregular siliceous laminae and mottles; rock bodies are regularly bedded.	Subtype B-1f includes a small percent of the exposed rock in the member.
B-1i	Dolomite, medium gray (N5), weathering yellowish gray (5Y8/1), consists of subangular fragments of laminated, very finely megacrystalline dolomite enclosed in a somewhat coarser matrix and intermixed with angular dark chert fragments in places; rock bodies in regular beds; also occurs in lenses.	Subtype B-1i includes a small proportion of exposed rocks in the member and occurs in the lower part.
B-2a, B-2b, B-2c B-2d, B-2e	Dolomite, medium gray (N5) to dark gray (N3), medium and coarsely megacrystalline (1/4 to 1 mm.), weathering medium light gray (N6), with "gritty" to "vuggy" weathering surface, very slow to spotty, moderate effervescence in cold dilute HC1, indistinctly bedded with extensively fractured, "lumpy" appear-	Type B-2 includes about 80 percent of the exposed member, increasing in proportion toward base.

Table 2 (cont'd.)

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
	ance; subnodular masses and rosettes of light-colored chert characteristic; may be structureless (B-2a), with poorly defined or discontinuous laminae (B-2b), with irregular to mottled siliceous structures (B-2c); may possess a para-arenitic or para-conglomeratic appearance on the fresh surface with darker colored grains (B-2d); and characteristically carries disseminated, irregularly tapering, micro-fractures filled with sparry dolomite; micro-fractures randomly arranged or subparallel and subperpendicular to bedding (B-2e). Rock bodies in poorly defined beds.	
B-3b	Limestone, dolomitic-mottled, medium gray (N5), smoothly fracturing cryptogranular with scattered and clustered sparry calcite, weathering light gray (N7); yellowish-weathering lobes and lenses of megacrystalline dolomite; several dolomitized gastropods; rock bodies in poorly defined beds and large, irregular lenses.	Subtype B-3b includes rock in two zones in the lower member at Wyomissing and in contact with Stonehenge limestone at Glenside; greater proportion in member suggested by extensive concealment characteristic of outcrop belt of member.

PLATE 7

Figure 1

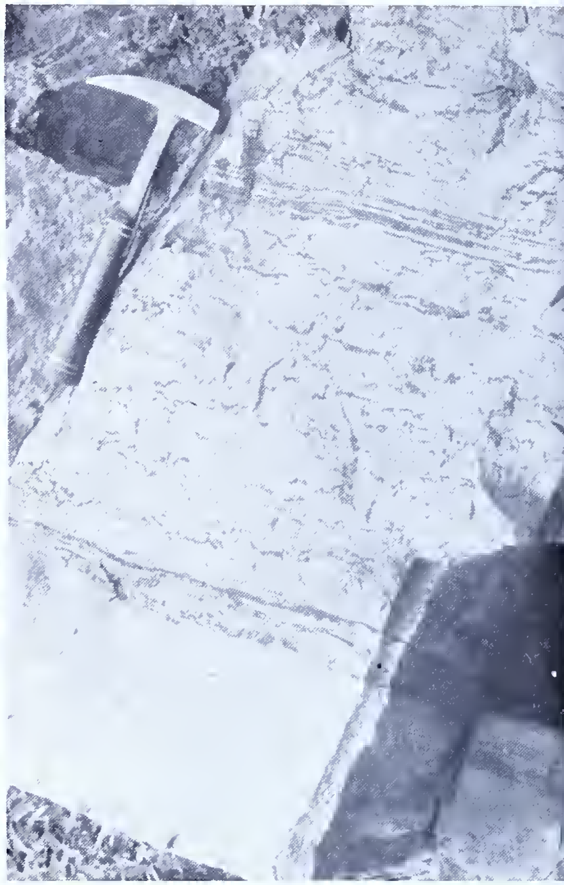


Figure 2

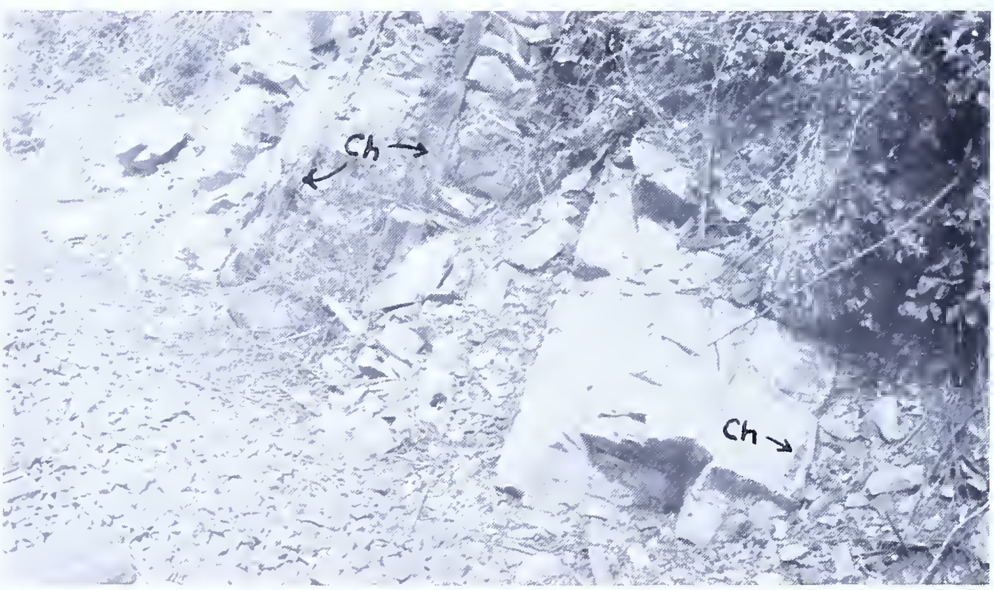


Figure 3

generally are medium-gray to medium-dark-gray, medium megacrystalline dolomite (B-2) in poorly bedded rock layers. The contact between the members, essentially transitional, is indicated by a noticeable change in the proportions of the two rock types B-1 and B-2 (Fig. 10).

Quartzose dolomite is confined to a zone about 109 feet thick with its base about 80 to 90 feet above the lower contact of the upper member at Epler School, section No. 3. In the described sections, beds of chert are confined to the upper member although there is evidence from a section unknown in detail that there may be chert beds in the lower member also.

Dolomitic-mottled limestones occur about 120 feet above the base of the lower member at Wyomissing, section No. 11 and at the contact with Stonehenge limestone at Glenside, section No. 1. Poor exposure of the lower member, characteristic throughout its belt of outcrop, may indicate a greater proportion of dolomitic limestone or calcitic dolomite than is evident from the exposures.

The possible significance of the above-described relationships between dolomite rock types in dolomite formations in the search for dolomite oil reservoirs has been noted in a recent paper (Hobson, 1961).

Petrology of the Epler Formation

Rock Types and Rock Subtypes

The Epler Formation, as studied chiefly at Epler School, section No. 4, is composed chiefly of rocks of five types. The rock types and subtypes are summarized in the following list, in which the types are listed in order of decreasing volumetric importance.

PLATE 7

Figure 1.—Bed composed of rock of subtype B-2c or B-2e. Lumpy-weathering, sandy-feeling surface is characteristic of rocks of type B-2. Small nests of light-colored chalcedonic quartz somewhat resemble pebbles in the photograph. Strata dip steeply to the observers left. Bed occurs in the middle part of the lower member of Rickenbach Dolomite at Rickenbach, section No. 2.

Figure 2.—Discontinuous, dark siliceous laminae and siliceous mottles, the latter in a sub-banded to sub-laminated distribution, in finely megacrystalline dolomite. Beds occur in lower part of the upper member of the Rickenbach at section No. 2 in association with irregular chert beds (see Fig. 3, below).

Figure 3.—Irregular beds of dark chert (ch.), rock type B-7, above lower contact of upper member of Rickenbach Dolomite at Rickenbach, section No. 2. Interbedded dolomites are well-bedded, very finely megacrystalline and commonly display color mottling and chert nodules similar to those (ch) in bed in foreground. Strata are overturned with younger beds to the observer's right.

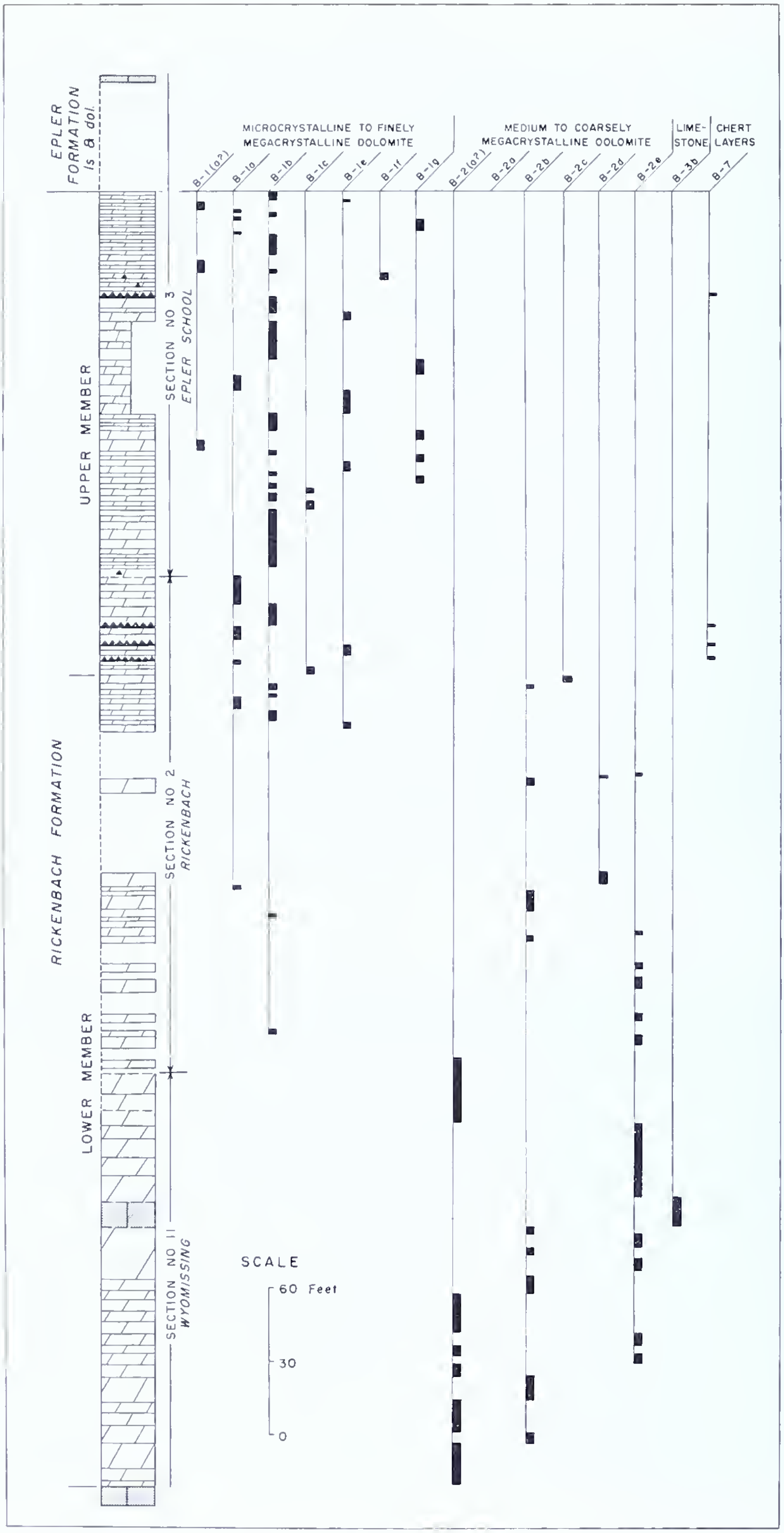


Figure 10. Distribution of rock subtypes in a composite section of Rickenbach dolomite.

Table 3

Rock subtypes of the upper member, Rickenbach Dolomite at Rickenbach and Epler School

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
B-1a, B-1b, B-1e, B-1f, B-1g, B-1h	Dolomite, medium gray (N5) to medium light gray (N6), microcrystalline to finely megacrystalline (less than ¼ mm.), most rocks very finely megacrystalline (1/16 to ⅛ mm.), weathering yellowish gray (5Y8/1) with some light-gray (N7) -weathering rock, trace of effervescence in cold dilute HCl; rock bodies in regular beds; may lack sedimentary structures (B-1a) or be color laminated (B-1b) and color mottled (B-1c); some rock with cherty laminae or irregular to reticulate cherty mottles (B-1f); arenaceous laminae and bands and scattered quartz grains (B-1g); some rocks with rounded calcitic grains giving weathered appearance a pitted appearance (B-1h); rock bodies commonly gash-jointed.	Rock type includes about 95 percent of the exposed rock in the member at Epler School.
B-2a, B-2b	Includes light-colored, medium megacrystalline rock weathering yellowish gray, commonly with laminae.	Rare, includes rock in lenses and in one or two beds.
B-7	Chert, medium gray (N5) to black (N1), microcrystalline, breaking with sharp conchoidal fracture into angular fragments, commonly stained reddish on a "vuggy" weathering surface but mostly with smooth black weathering surface; cccurs in irregular beds; petrographically similar to dark chert nodules and stringers.	Includes about 4 percent of the rock in the lower part of the member.

Dolomite (B-1) microcrystalline to finely megacrystalline:
- (B-1a) apparently structureless
- (B-1b) regularly laminated
- (B-1c) calcitic-laminated
- (B-1d) calcitic-mottled
- (B-1e) light- and dark-mottled
- (B-1h) calcarenitic (calcite-sand-bearing)

Limestone (B-4) roughly fracturing cryptogranular:
- (B-4a) silty-laminated and siliceous-laminated and-mottled
- (B-4b) dolomitic-mottled
- (B-4c) dolomitic-laminated and -banded
- (B-4d) silty-argillaceous-laminated

Limestone (B-5) calcarenitic, medium to coarsely megacrystalline:
- (B-5a) dolomitic-laminated and-banded
- (B-5b) dolomitic-mottled
- (B-5c) silty-argillaceous-laminated

Limestone (B-3) smoothly fracturing cryptogranular:
- (B-3a) apparently structureless
- (B-3b) dolomitic-mottled
- (B-3d) siliceous-laminated to -mottled

Limestone (B-6) calciruditic:
- (B-6a) silty-argillaceous-laminated
- (B-6b) dolomitic-mottled

The megascopic characteristics and proportions of the rock subtypes are presented more fully in Table 4. Examples of the subtypes are shown in Plate 8.

PLATE 8

Figure 1.—Strata of subtype B-3d, siliceous-mottled limestone. Note distortion of reticulate mottling, which stands in strong relief, parallel to the trace of rock cleavage; S_1—bedding trace and S_2—trace of cleavage. Lithology is similar to that of parts of the Stonehenge Limestone (Plate 6). Rock occurs 101 feet above base of the Epler Formation at Epler School, section No. 4.

Figure 2.—Bed of dolomite of subtype B-1b to B-1h showing thin, regular laminae. A large proportion of the darker laminae are calcitic or of calcite and weather inward. Thin "dikes" of dolomite transect the laminae in places. The upper surface of the bed shows indistinct mudcracking. Bed is 547 feet above the base of the Epler Formation at Epler School, section No. 4.

Figure 3.—Beds of dolomitic-mottled limestone showing "fucoidal" arrangement of cyclindrical and tubular structures of dolomite on the bedding surface. "Fucoids" are common in the dolomitic-mottled limestone of the Epler, especially in the lower one-half of the formation. Beds in photograph are 392-½ feet above the base of the Epler at Epler School, section No. 4.

PLATE 8

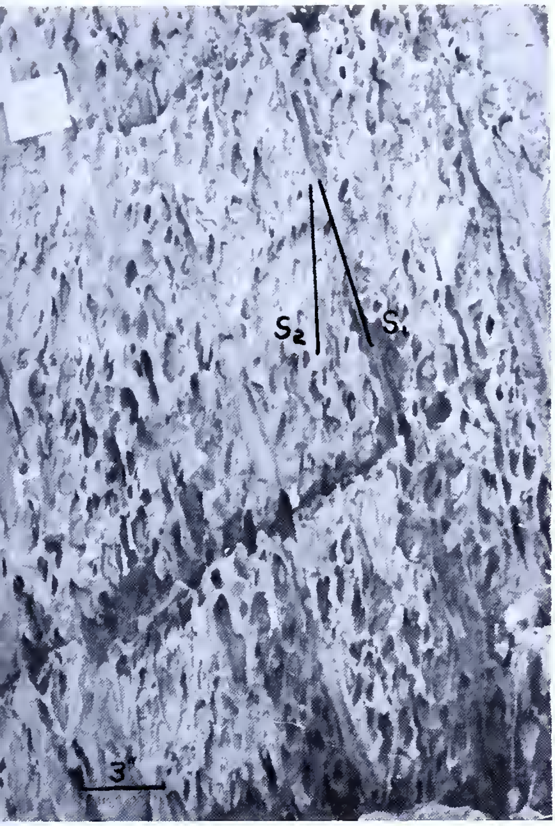


Figure 1

Figure 2

Figure 3

Table 4

Rock subtypes of the Epler Formation at Epler School

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
B-1a, B-1b, B-1e	Dolomite, rock similar in all essential respects to that of corresponding subtype numbers in the Rickenbach dolomite; somewhat larger proportion of laminated rock in the Epler formation; dark chert in subnodules and rosettes associated with most subtypes; rock bodies occur in regular beds.	Type B-1 includes about 40 to 45 percent of exposed rock in the lower one-half and about 25 to 30 percent of the exposed rock in the upper one-half.
B-1c	Dolomite, calcitic-laminated, medium gray (N5) to medium light gray (N6), microcrystalline to finely megacrystalline (less than ¼ mm.), weathering yellowish gray (5Y8/1) with thinly ridged surface; millimeter-thick alternations of dolomite, calcite, and mixtures of dolomite and calcite; rock bodies occur in well-defined beds.	Subtype B-1c includes about 3 percent of exposed rock.
B-1d	Dolomite, calcitic-mottled, medium gray (N5), very finely to finely megacrystalline (1/16 to ¼ mm.), weathering yellowish gray (5Y8/1) with lenses of limestone weathering inward from the surface; calcitic-mottled dolomites include all mottled rock in which dolomite forms greater than 50 per cent of the rock as estimated visually; with an increasing limestone content the rock grades into subtype B-3b or B-4b, dolomitic-mottled limestone; rock bodies in irregular layers and beds.	The percentage of rock composed of subtype B-1d is not clearly established but samples of this subtype make up about 5 percent of the total number of samples.

Table 4 (cont'd.)

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
B-1h	Dolomite, calcarenitic, medium gray (N5), very finely to finely megacrystalline (1/16 to ¼ mm.), pitted surface due to selective weathering of calcite sand and conglomerate grains; most often in mottling and subbands comprising 50 per cent or more of the sample as estimated megascopically; with increased calcite content rock grades into dolomitic calcarenite, rock subtype B-3b; occurs in regular layers and in lenses.	The percentage of rock composed of subtype B-1h is not clearly established but it may make up about 5 percent of the exposure.
B-3a, B-3b, B-3d	Limestone, smoothly fracturing cryptogranular with scattered and clustered sparry calcite, breaking under hammer with characteristic conchoidal fracture, dolomitic-mottled, silicecus-mottled, medium gray (N5) to medium light gray (N6), recrystallized in some places into very finely megacrystalline limestone, weathering very light gray (N6); gastropods and indistinct fragmental lenses common; rarely lacking sedimentary structure (B-3a), with yellowish-gray-weathering dolomite mottles (B-3b), rarely with subreticulate siliceous mottles (B-3d); rock of subtype B-3b forms transitional zones with rock of subtype B-1d and occurs in well defined layers.	Type B-3 includes rock that makes up about 21 percent of lower one-half and is also common in the upper one-half.
B-4a, B-4c	Limestone, rock similar in all essential respects to those with corresponding subtype members in Stonehenge formation; greater proportion of dolomitic-laminated to -banded samples in Epler.	Type B-4 includes rock that makes up about 20 percent of the upper one-half and 12 percent of the lower one-half.
B-4b	Limestone, dolomitic-mottled, medium gray (N5), roughly fracturing cryptogranular to very finely megacrystalline, with lighter colored dolomitic- mottles of variable morphology; with increasing dolomite content, rock grades into calcitic-mottled dolomites, subtype B-1d; rock bodies in regular layers.	Subtype B-4b includes rock that makes up about 13 percent of the upper one-half and 11 percent of the lower one-half.

Table 4 (cont'd.)

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
B-4d	Limestone, silty-argillaceous laminated, medium gray (N5) and medium dark gray (N4), roughly fracturing cryptogranular; irregular, wavy, discontinuous silty-argillaceous laminae contain variable amounts of dolomite as evidenced by yellowish and brownish weathered appearance; some rock with silty laminae; takes on hard siliceous-laminated aspect in some horizons similar to subtype B-4a.	Subtype B-4d includes rock that makes up about 14 percent of the upper one-half exposures and 7 percent of the lower one-half.
B-5a, B-5b, B-5c	Limestone, medium gray (N5), medium to coarsely megacrystalline, (¼ to 1 mm.) on fresh surface, fragmental limestone with pelmatozoan, gastropod, and trilobite debris, with dolomitic laminae and bands (B-5a), intergranular and intragranular dolomitic mottling (B-5b) grading into subtype B-1d in some samples, silty-argillaceous laminae (B-5c) with variable amounts of dolomite; rock bodies in thin, irregular beds.	Type B-5 includes rock that makes up a minimum of 25 percent of exposures of the upper one-half and 5 percent of the lower one-half.
B-6a, B-6b	Limestone, flat-pebble conglomerate, somewhat similar to rocks of corresponding subtype numbers in Stonehenge formation, dolomitic-mottled (B-6b) and silty-argillaceous laminated (B-6a); rock bodies occur as thin, irregular beds.	Confined to upper member in descriptions of field sections but making up about 30 percent of fragmental limestone samples.

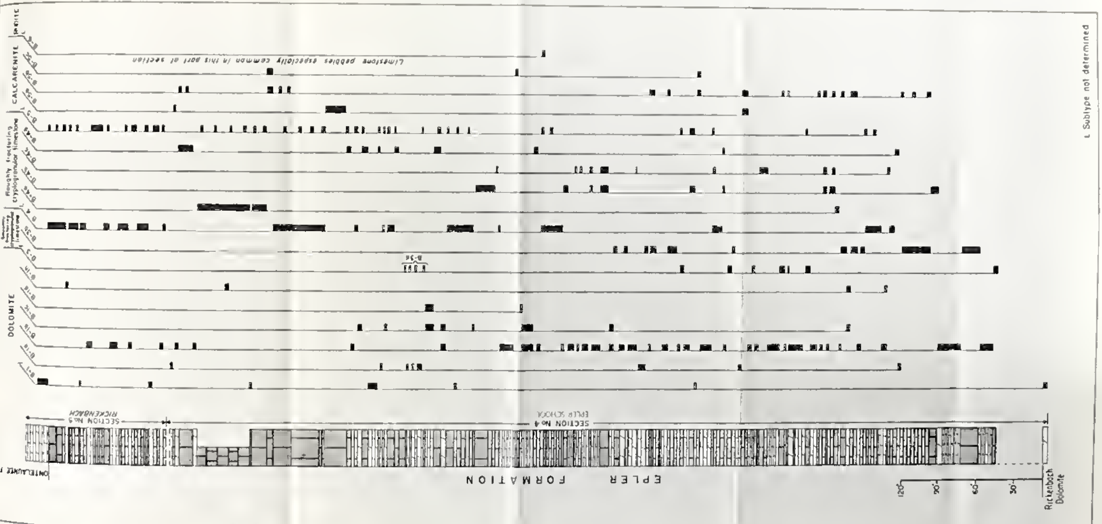


Figure 11. Generalized distribution of rock subtypes in the Epler Formation at Epler School and at Rickenbach.

Table 4 (cont'd.)

Distribution of Rock Subtypes

Distribution of rock types in the type section of the Epler Formation at Epler School is shown in Figure 11. The lower one-half of the Epler contains a greater proportion of dolomite, rock type B-1, and smoothly fracturing cryptogranular limestone, rock type B-3, than does the upper one-half. The exposed limestones of the upper one-half are generally roughly fracturing cryptogranular, rock type B-4, and fragmental, rock types B-5 and B-6.

Beds of dolomite, B-1, make up about 40 to 45 percent of the exposures of the lower part of the Epler at Epler School. Calcitic dolomites and dolomitic limestones increase the overall dolomite content still further. Layers of dolomitic-mottled limestone and calcitic-mottled dolomite are especially conspicuous at the contacts of the limestone and dolomite bodies. A count of 86 dolomite-limestone contacts in the lower part of the Epler indicates that the majority of the lower limestone contacts are unmottled and the upper contacts are subequally mottled and unmottled. Figure 12 illustrates diagrammatically the relation of limestone, dolomite, and mottled rock in the formation. Actual rock body "cycles" are shown in Plate 9.

The upright asymmetrical cycle, as defined in Figure 12, is of particular interest. As indicated by the description of the Epler at Epler School, there are at least 16 of these cyclic deposits of which 14 are in the lower one-half of the formation.

In order to examine the upright asymmetrical cycle in greater detail, samples were taken at 6-inch intervals perpendicular to bedding through two cycles. Etched and thin sections were prepared from the samples. The compositional and textural-morphological components were then described and point counted. The results of the analysis of one of the cycles is shown in Figure 13; the detailed petrology of the samples is presented in Appendix 1.

Eight samples were studied from this cycle. The percentage of dolomite and the percentage in the calcite fraction of clastic grains, bioclastics, and lime mud for each of the samples is shown in Figure 13. The cycle begins at the base with dolomitic calcarenite grading upward through dolomitic calcilutite and calcilutitic dolomite into dolomite. As shown in the photograph of Figure 13, the dolomite of this cycle is overlain abruptly by calcarenitic limestone with regular siliceous laminae.

The dolomite in the dolomitic limestones is disposed in mottles. The mottling is in the form of interconnected lobes and stringers near the base of the cycle becoming somewhat reticulate near the top. A so-called fucoidal arrangement of the dolomite on the bedding surface is pronounced in the

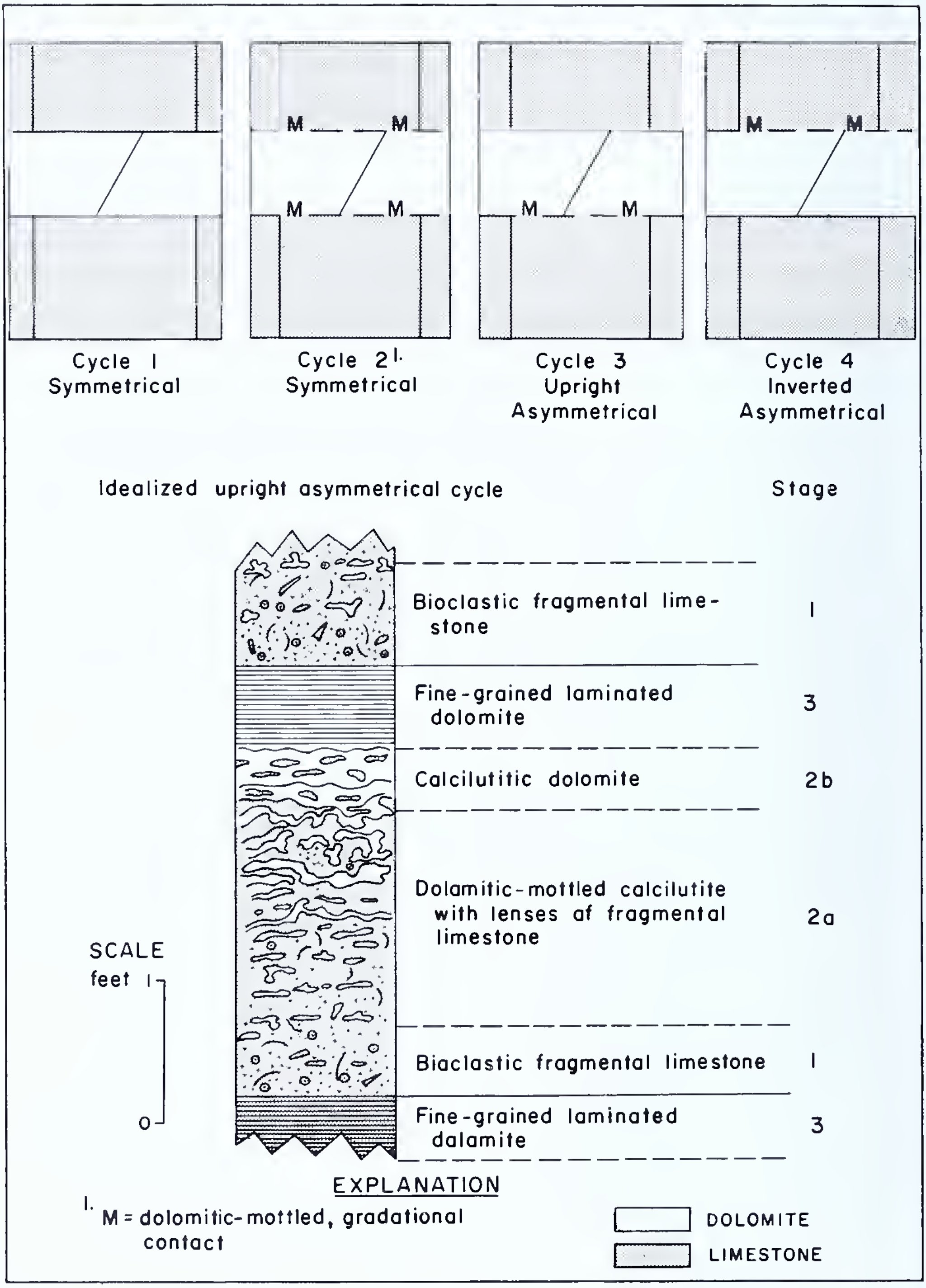


Figure 12. Cyclic sedimentary deposits in the Epler Formation at Epler School (Section No. 4).

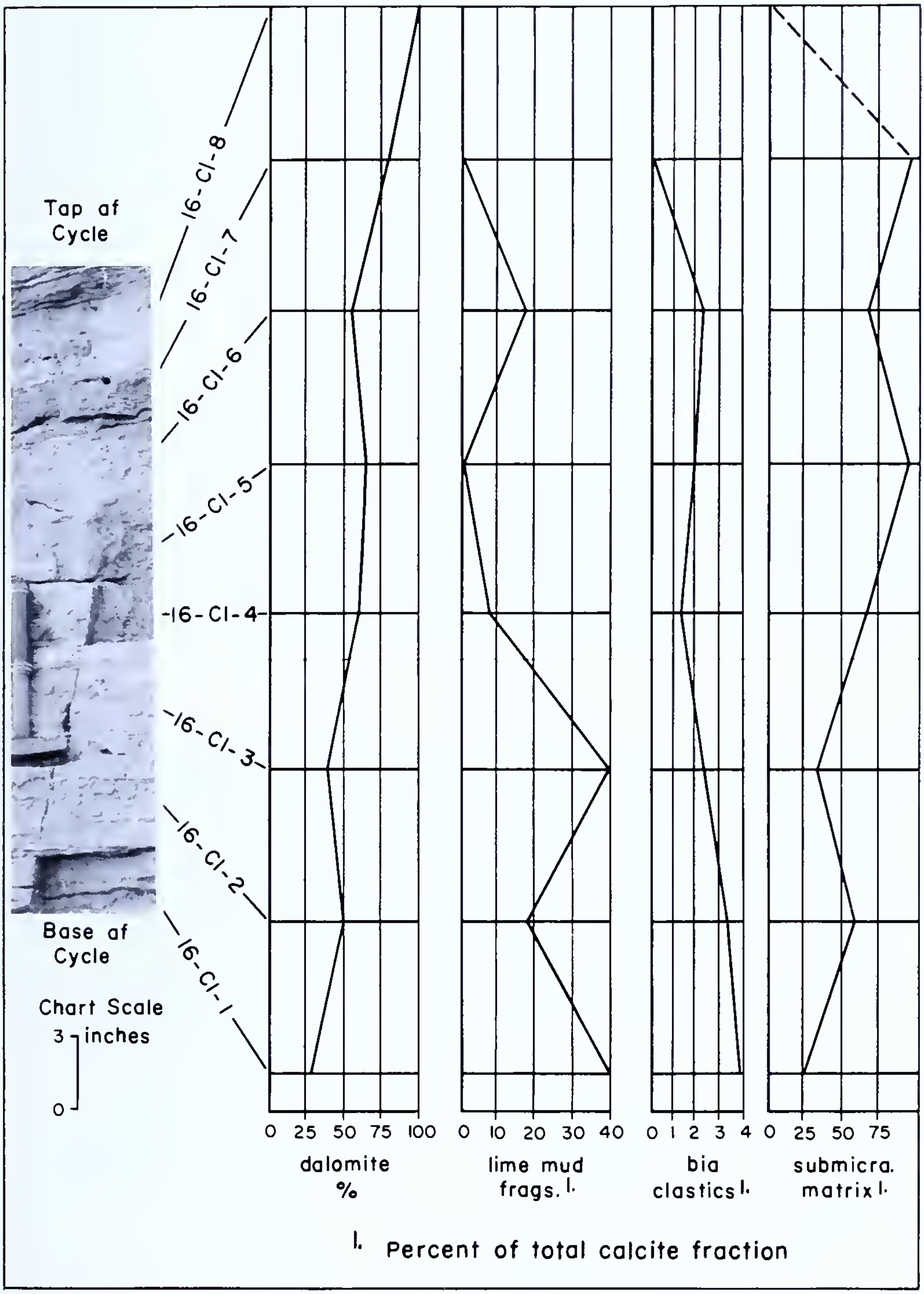


Figure 13. Illustrative cycle No. 1, lower member of the Epler Formation at Epler School (Section No. 4).

PLATE 9

Figure 1

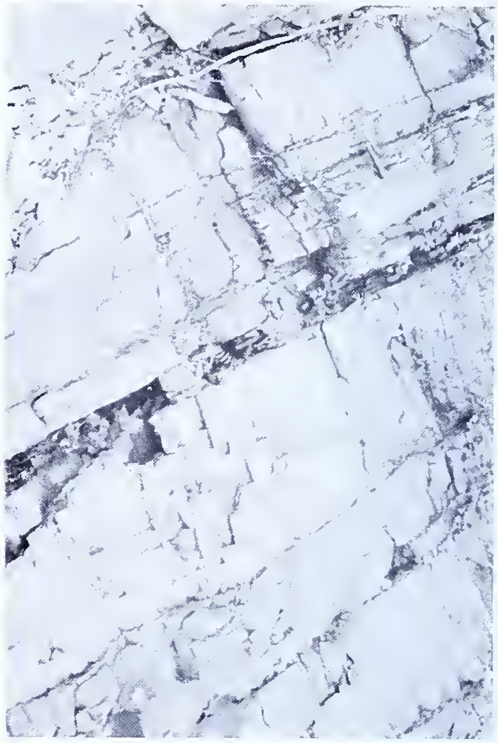


Figure 2

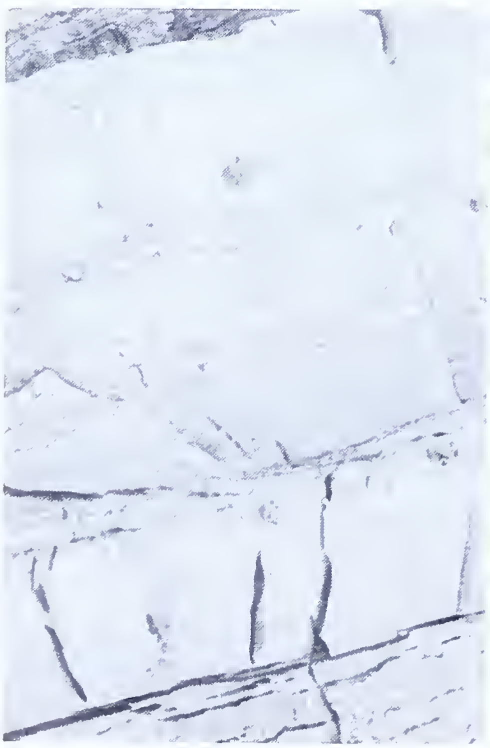


Figure 3

Figure 4

cycle. The formation of dolomite apparently has proceeded beyond the tubular and cylindrical structures in places with dolomitization of the surrounding calcite.

The two cycles studied have the following characters in common: (1) an overall increase in dolomite percentage upward through the cycle, (2) a decrease in clasticity and bioclastics in respect to lime mud in the calcite fraction upward through the cycle, (3) an upper bed of fine-grained dolomite, rock type B-1, (4) a sharp base and top delimited by sharp, unwelded contacts, along which there is little evidence of erosion of the dolomite beds, (5) fucoidal structures that suggest activity of organisms, and (6) pyrite in the lime mud and dolomite fractions.

The cycles are believed to give invaluable clues for understanding the tectonic and sedimentary environments. A discussion of the probable genesis of the cycles and rock types of the Epler is included in the discussion of paleogeography, environments of deposition, and tectonic background.

Petrology of the Ontelaunee Formation

Rock Types and Rock Subtypes

The three members of the Ontelaunee Formation are composed of rocks of four rock types and eight rock subtypes. The types, but not the subtypes, are listed in order of decreasing volumetric importance as follows:

PLATE 9

Figure 1.—Upright asymmetrical cycle in the lower one-half of the Epler Formation. Bed of dolomite (Dl) is overlain along abrupt, unwelded contact by fragmental limestone with dolomite mottles which increase in proportion upward into the thin bed of dolomite (Dm) at hammer head. The upper dolomite (Du) and middle beds of dolomite are separated by dolomitic-mottled cryptogranular limestone. Sample No. 110 is 294-½ feet above the base of the Epler at Epler School, section No. 4.

Figure 2.—Inverted asymmetrical cycle at hammer overlain by a symmetrical cycle; stratigraphically younger beds toward base of photograph. Proportion of dolomite mottles in limestone above sample No. 85 mark increases upward and along bedding. The closely spaced joints are characteristic of the massive, homogenous dolomites of the Beekmantown. Sample No. 85 mark is 195 feet above the base of the Epler Formation at Epler School, section No. 4.

Figure 3.—Upright asymmetrical cycles in the lower one-half of the Epler Formation at Epler School, section No. 4. Upper part of the older cycle is at the base and the lower part of the overlying cycle is at the top of the photograph. Cycles occur in the lower part of the Epler Formation at Epler School, section No. 4.

Figure 4.—Upright asymmetrical cycle about 136 feet above the base of the Epler Formation at Epler School, section No. 4. Sharp contact at base of cycle is visible in center of photograph; mottled zone is at hammer head. Dark, irregular, styolitic, silty-argillaceous laminae are common in the limestones.

Dolomite (B-1) microcrystalline to finely megacrystalline:
- (B-1a) apparently structureless
- (B-1b) light- and dark-laminated
- (B-1c) light- and dark-mottled
- (B-1f) siliceous-laminated and -mottled
- (B-1i) brecciated

Dolomite (B-2 medium megacrystalline:
- (B-2a) apparently structureless
- (B-2c) siliceous-mottled
- (B-2e) micro-fractured

Limestone (B-3) smoothly fracturing cryptogranular and very finely megacrystalline:
- (B-3b) dolomitic-mottled

Chert (B-7) microcrystalline aggregates occurring in layers

The megascopic characteristics and proportions of the rock subtypes are presented more fully in Table 5.

Distribution of Rock Subtypes

Figure 14 shows the distribution of rock subtypes in the Ontelaunee Formation of central Berks County.

The lower member, as studied principally at Tuckerton, section No. 7, and Leesport, section No. 6 and No. 9, is composed predominantly of well bedded, medium-gray to medium-light-gray, very finely megacrystalline dolomite, rock type B-1, with some interbeds of darker, medium megacrystalline dolomite, rock type B-2, and dark microcrystalline chert, rock type B-7. At Leesport, in sections No. 6 and No. 9, the dolomite and chert are commonly brecciated along the bedding. Angular blocks of chert are enclosed in dolomite and angular fragments of dolomite are surrounded by chert. The lower contacts of the chert beds are typically even, whereas the upper parts are irregular and nodular and, in some instances, contain blocks of the overlying dolomite body engulfed in chert. Cauliflower cherts occur in the member in sections No. 6 and No. 9. In places the chert beds enclose lenses of dolomite up to a foot in length and grade along bedding into dolomite with reticulate mottling of chert.

The majority of the middle member is composed of dolomite of rock type B-1.

Table 5

Rock subtypes of the Ontelaunee Formation at Leesport and Stoudt's Bridge

Rock Subtype Number	Rock Subtype Description	Rock Subtype Occurrence
B-1a, B-1b, B-1e B-1f, B-1i	Dolomite, rocks similar in all essential respects to those of corresponding subtype numbers in the upper and lower members of the Rickenbach formation; a somewhat larger proportion of rock lacking sedimentary structure (subtype B-1a) is present in the Ontelaunee formation; rock is typically gash weathered along closely spaced joints.	Type B-1 includes rock that makes up about 85 percent of upper member, 95 percent of middle member, and 85 percent of lower member exposures.
B-2a, B-2c, B-2e	Dolomite, rocks similar in all essential respects to those of corresponding subtype numbers in the lower members of the Rickenbach formation.	Type B-2 includes rock that makes up about 10 percent of exposures in lower member where it is associated with chert beds.
B-3b	Limestone, dolomitic-mottled, medium gray (N5) to medium light gray (N6), smoothly-fracturing cryptogranular to finely megacrystalline; scattered dolomitized fossils, chiefly gastropods; interconnected lobes and lenses of megacrystalline, yellowish-gray (5Y8/1) -weathering dolomite; rock bodies in regular beds.	Subtype B-3b includes rock that makes up 5 percent or slightly more of exposures of upper member.
B-7	Chert, rock similar in all respects to that with a corresponding subtype number in the upper member of the Rickenbach formation; rock bodies in irregular beds.	Type B-7 includes rock that makes up about 2 to 4 percent of exposures of lower member.

The upper member contains numerous thin beds of dolomitic-mottled, sparsely fossiliferous, smoothly fracturing cryptogranular and very finely megacrystalline limestone, rock subtype B-3b. The dolomites belong largely to rock type B-1. Closely spaced, "gash-weathered" joints are characteristic in the dolomite giving the appearance of bedding in small exposures. Layers of brecciated dolomite, rock subtype B-li, are fairly common.

Comparison of the Ontelaunee and Rickenbach Formations in terms of Distribution of Rock Types

Two points of comparison can be made concerning the distribution of rock types in the Ontelaunee and Rickenbach Formations.

First, in both formations, a unit of interbedded, fine-grained dolomite (rock type B-1) and coarser grained dolomite (rock type B-2) occurs at the base and is overlain by a unit of fine-grained dolomite. The proportion of coarser grained dolomite, however, is much greater in the Rickenbach than in the Ontelaunee.

Second, the upper unit of fine-grained dolomite grades upward into interbedded, mottled limestone (rock type B-3b) and fine-grained dolomite. In the case of the Rickenbach Formation the interbedded zone is included in the overlying Epler Formation, whereas in the Ontelaunee it is included in an upper member of the formation.

Although the general sequence of bodies of these rock types is similar in both formations, the division into a lower, coarser grained part and an upper, finer grained part is much more pronounced in the Rickenbach.

A paleogeographic interpretation of this apparent cyclicity is discussed after treatment of the regional relations of the rock bodies.

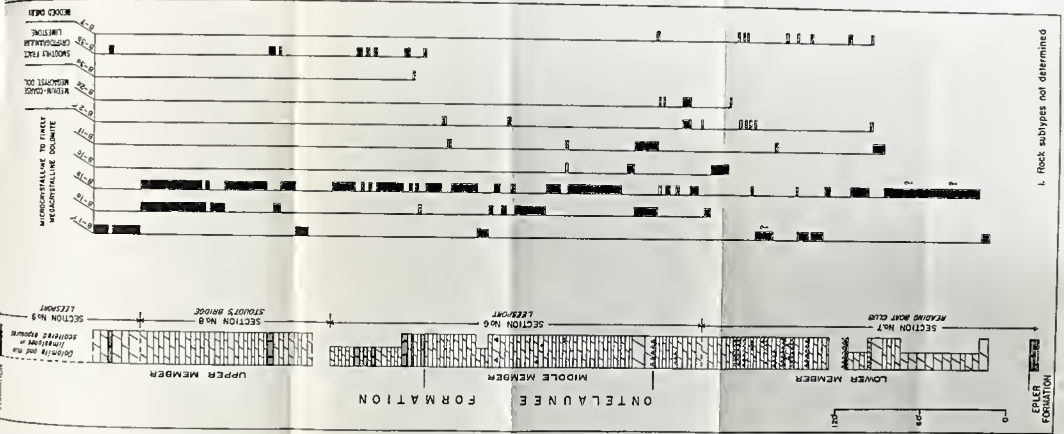


Figure 14. Generalized distribution of rock subtypes in the Ontelaunee Formation.

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REGIONAL STRATIGRAPHY OF THE BEEKMANTOWN GROUP

Regional Stratigraphy of the Stonehenge Formation

Introduction

Prior to this study, the Stonehenge Limestone had been identified in three parts of the Great Valley of Pennsylvania.

Stose (1908) in recognizing the Beekmantown Limestone in south-central Pennsylvania, differentiated a lithologic unit at the base which he termed the Stonehenge Member from exposures near the former town of Stonehenge, an area now included in Stoufferstown, eastern Franklin County. Sando (1958) in a lithologic and paleontologic study of the Beekmantown east of Chambersburg, Franklin County, has raised the Stonehenge to formational status in that area.

Stonehenge Limestone has been mapped by Stose (1953) in the Carlisle quadrangle, northeast of Franklin County.

East of the Susquehanna River in Lebanon County, a body of limestone of Stonehenge lithology and stratigraphic position had been recognized by Gray and others (1954). Following identification of the Stonehenge Limestone in Berks County (Hobson, 1957), the name Stonehenge has been applied to the beds in Lebanon County and has been mapped through that county and into eastern Dauphin County (Gray and others, 1958; Geyer and others, 1958).

The formation has now been identified on the 1960 Geologic Map of Pennsylvania in the main belt of Beekmantown rocks from Franklin County northeastward to the Schuylkill River.

In the following sections, lithologic and paleontologic characters of the Stonehenge in Franklin and Lebanon Counties are reviewed and consideration is given to regional changes in thickness from southcentral Pennsylvania northeastward. The generalized rock sequences in the Stonehenge of these areas are represented by columnar sections in Figure 15.

Stonehenge Limestone in Eastern Franklin County

General lithology and rock succession

The Stonehenge Limestone, as described by Sando (1958) in eastern Franklin County is represented by the columnar section in Figure 15. Sando has divided the formation into two members. The lower member, termed the Stoufferstown Member, is composed almost entirely of limestone conglomerate and arenite. The upper member (unnamed) contains, in addition to clastic limestone, subordinate amounts of algal limestone or lutite. These rock types are discussed fully by Sando (1957) in his study of the Beekmantown in Maryland.

Contacts and thickness

The upper contact of the Stonehenge Limestone in the exposures east of Chambersburg has been placed by Sando (1958) at the base of the lowest dolomitic limestone of the Rockdale Run Formation of the Beekmantown Group and below a prominent zone of cryptozoon chert. The lower contact has been placed by Sando between the fossiliferous Stoufferstown Member and the underlying unfossiliferous Conococheague limestone of Cambrian age. Strata comprising the Stoufferstown Member of Sando were previously regarded as upper Conococheague by Stose (1908) in Pennsylvania and by Bassler (1911) and Sando (1957) in Maryland.

Sando (1958) reports that the Stonehenge as newly defined near Chambersburg is about 1000 feet thick, of which the Stoufferstown member makes up about 220 feet.

Paleontology

Fossils have been reported from the Stoufferstown and upper members of the Stonehenge by Sando (1958).

Hyolithes sp., *Finkelnburgia* sp., inarticulate brachiopod fragments, an ophiletid gastropod fragment, an orthoceracone cephalopod, and merostome fragments as well as *Pseudokainella* ? and conodonts have been reported by Sando (1958) from a fossiliferous bed 62 feet above the base of the Stoufferstown Member in the Franklin County exposures. *Pseudokainella* ? and the conodonts indicate a Lower Ordovician age for these beds (Sando, 1958). *Symphysurina* and *Clelandia* found in beds near the top of the Stoufferstown Member in Maryland (Sando, 1957) are characteristic of a widespread zone near the base of the Lower Ordovician series.

In the upper member of the Stonehenge in Franklin County, *Bellefontia collieana, Finkelnburgia Bridgei, F. stonehengensis* and lytospirid gastropods are most abundant; conodonts are common in the upper 200 feet of the member (Sando, 1958).

Possible relations between fossiliferous Stonehenge beds in southern Pennsylvania and those in Berks County are discussed in a later section.

Stonehenge Limestone In Lebanon and Dauphin Counties

General lithology

Knowledge of the Stonehenge of Lebanon County is dependent on scattered exposures. At Richland, section No. 14, a quarry and railroad cut expose about 100 feet of megacrystalline, medium-gray and medium-light-gray, somewhat metamorphosed limestone containing chert nodules, dolomitic mottles,

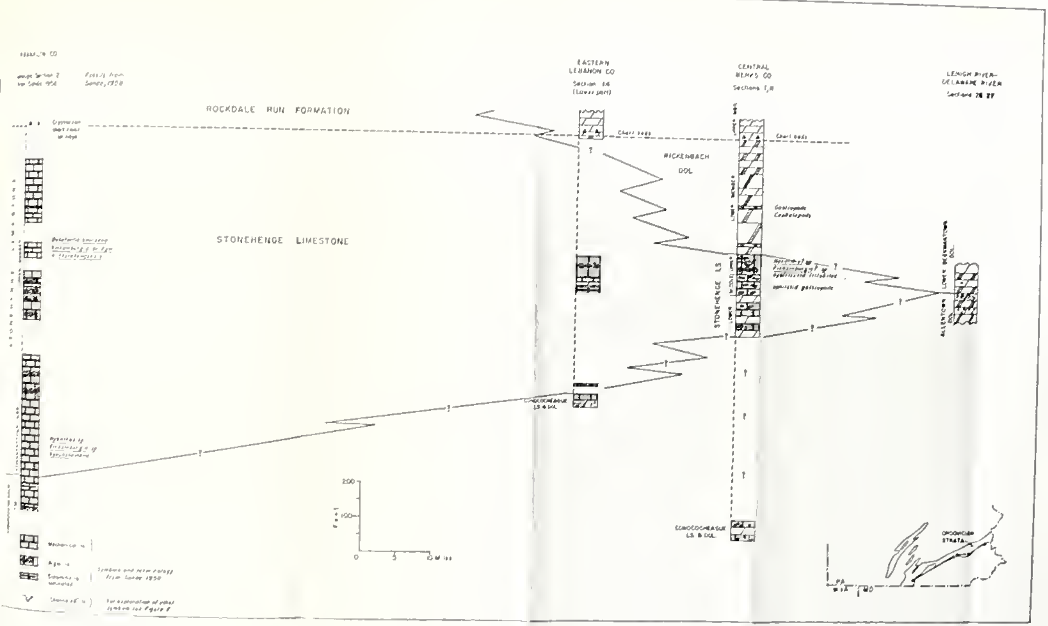

Figure 15. Regional stratigraphy of Stonehenge limestone from Franklin County, southern Pennsylvania, to the Lehigh River and Delaware River areas.

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and dolomitic and siliceous laminae. Several beds of very finely megacrystalline, laminated, yellowish-weathering dolomite occur in the exposures. The quarry beds occur about midway between exposures of Rickenbach dolomite and Conococheague dolomite. East of the quarry, essentially horizontal beds of flat-pebble limestone conglomerate with pelmatozoan plates are adjacent to steeper dipping beds of Conococheague limestone and dolomite. The basal part of the formation is reportedly characterized by beds of edge-wise conglomerate (Gray and others, 1958; Geyer and others, 1958). A small quarry 1.8 miles southeast of the railroad crossing in Richland exposes megacrystalline, calcarenitic beds in the Stonehenge belt of outcrop.

Reportedly, dolomites make up less than 20 percent of the formation, increasing in number toward the top (Gray and others, 1954).

Contacts and Thickness

The lower contact can be defined only with some difficulty owing to poor exposures and complex structure. For mapping purposes the base of the Stonehenge has been placed at the bottom of the lowest thick bed of medium-light-gray, crinoid-bearing limestone above the dolomites of the Richland Member of the Conococheague Formation, and the top contact is placed at the base of the lowest thick dolomite bed of the Rickenbach Formation (Gray and others, 1958b).

The Stonehenge has been estimated to be at least 600 feet thick in Lebanon County (Gray and others, 1958; Geyer and others, 1958). The formation appears to be somewhat more than 700 feet as measured in section No. 14 at Richland.

Paleontology

Fossils are common throughout the formation; the majority of these appear to be low-spired gastropods (Gray and others, 1958; Geyer and others, 1958). As in Berks County, gastropods are associated with limestone conglomerate beds in the Stonehenge.

Regional Changes in Thickness and Rock Character

On the basis of present data, the Stonehenge, as defined in the areas where studied, thickens westward from about 250 feet in Berks County to at least 600 feet in Lebanon County and 1,000 feet in Eastern Franklin County (Fig. 15). A body of Stonehenge lithology and stratigraphic position is not present in the Lehigh River or Delaware River areas.

A modification in the limestone-dolomite ratio accompanies the change in thickness. The presence of bedded dolomite in the Stonehenge as defined in Lebanon and Berks Counties is the most striking lithologic difference from that

of the type area. Dolomite occurs in the greatest proportion near the base of the formation in Berks County, a fact that may be associated with an apparent increase in dolomite content in the underlying Conococheague Formation from Franklin County eastward to the Lehigh-Delaware River area. That the Conococheague Formation undergoes a northeastward increase in dolomite is indicated by the following observations: 1) As measured and described by A. Donaldson and the writer in Franklin County (technical report for the California Company), a 2070-foot section of the Conococheague Formation as defined by Stose (1908) and about 50 percent exposed contains but one thin bed of dolomite. 2) In Lebanon County the Richland Member of the Conococheague, comprising at least the upper 1300 feet of that formation near Richland, is predominantly dolomite (Gray and others, 1958). 3) As measured and described by the writer near Reading, Berks County, 280 feet of probable Conococheague, underlying the Stonehenge by an apparent thickness of 500 to 600 feet of covered beds, contains about 20 percent bedded dolomite. 4) As will be discussed in a following section, the upper Cambrian succession in the vicinity of the Lehigh and Delaware Rivers in eastern Pennsylvania consists almost completely of dolomite and apparently underlies, transitionally, dolomites similar to the Rickenbach in Berks County.

In addition to the greater amounts of bedded dolomite in strata underlying the Stonehenge, the overlying rocks also show an increase in proportion of dolomite northeastward from eastern Franklin County to central Berks County. The relations of the overlying rocks are treated in more detail in the following section concerned with the regional stratigraphy of the Rickenbach Formation.

The increase in dolomite beds of rocks above and below the Stonehenge from eastern Franklin County northeastward and the generally transitional upper and lower contacts of the formation where studied suggest that the change in thickness of the Stonehenge may be by change in facies with the Stonehenge Limestone disappearing by normal interfingering with dolomites northeastward. Apparently the Stonehenge disappears along the strike of the Great Valley somewhere northeast of the Schuylkill River and southwest of the Lehigh River.

Limestones in the Stonehenge, as exposed in eastern Franklin County, in Lebanon County, and in Berks County, appear generally similar in lithology, being composed of fine-grained, "algal" limestone and of clastic, fragmental limestones in varying proportions. The middle and upper members of the Stonehenge in Berks County bear a general resemblance, respectively, to the Stoufferstown and upper members in Franklin County. "Algal" limestone is confined largely to the upper unit of both areas; and, like the Stoufferstown Member of Franklin County, the middle member in Berks County is composed almost entirely of fragmental or clastic limestones.

Fossils identified from the Stonehenge of Berks County, including an ophiletid gastropod, at least one species of *Finkelnburgia,* and a hystricurid trilobite, confirm the identification of Stonehenge beds in that area but do not provide information for detailed correlation with Lower Ordovician fossil zones of Sando (1958) in Franklin County. The *Finkelnburgia* in the upper member in Berks County may represent the zone containing *Finkelnburgia bridgei* and *F. stonehengensis* in the upper member of the Stonehenge in Franklin County. Ophiletid gastropods occur in the Stoufferstown Member of Franklin County and in the middle member of the Stonehenge in Berks County. Nanorthid brachiopods are not listed for the Stonehenge of Franklin County by Sando but are common in the upper member of the Stonehenge in the Berks County sequence.

Regional Stratigraphy of the Rickenbach Formation

Introduction

The Rickenbach Formation has been identified in two parts of the Great Valley of Pennsylvania. In addition to its occurrence in the type area in central Berks County, a body of similar lithology and stratigraphic position had previously been recognized without close definition in Lebanon County to the west (Gray and others, 1954), and, following naming of the formation in Berks County, has been mapped through eastern Lebanon County under the name Rickenbach Formation (Gray and others, 1960). Dolomite similar in lithology and stratigraphic position to the Rickenbach of Berks County is present in measured sections in the Lehigh River and Delaware River areas.

In the following discussion, consideration is given to the rock characters and regional changes in lithology and thickness of the Rickenbach as studied in the areas mentioned in the preceding paragraph.

Rickenbach Formation in Lebanon County

General lithology

The best exposure of the Rickenbach Formation in Lebanon County is in the railroad cut, section No. 14, immediately west of the crossing in Richland in the eastern part of the county (Plate 10). The Rickenbach in this exposure has also been described in detail by Gray and others (1958). Beds of similar lithology and stratigraphic position to the Rickenbach in the Richland section have been described in section No. 19 located in the city of Lebanon, central Lebanon County. As shown on the 1960 Geologic Map of Pennsylvania, a mappable body of dolomite in this part of the section is not present in the central and western parts of Lebanon County. The studied sections in Lebanon County are represented by columnar sections in Figure 17.

PLATE 10

Figure 1

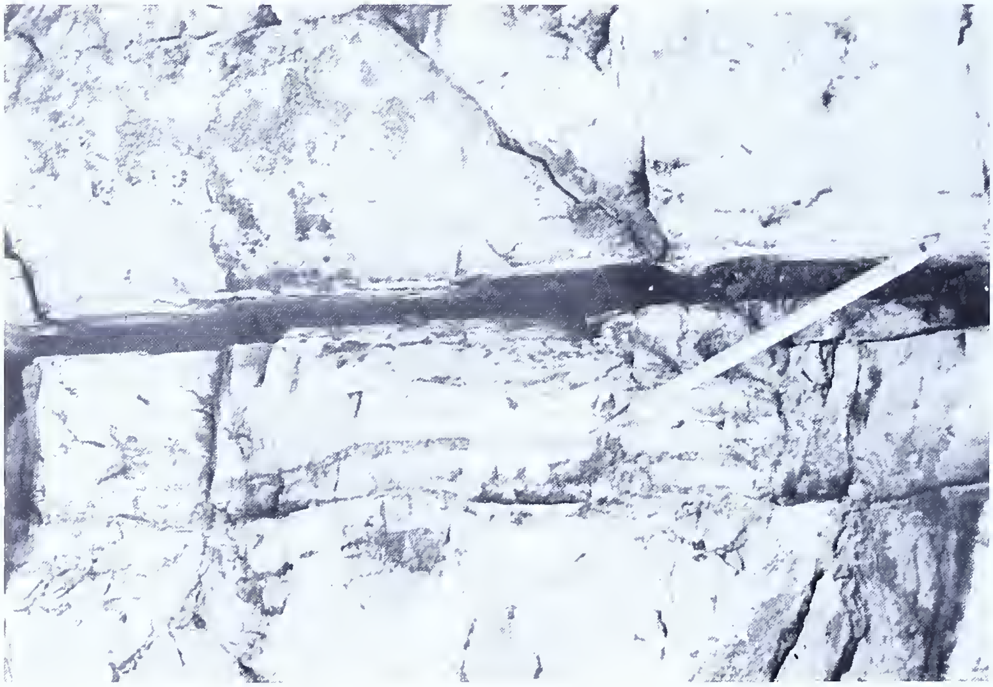

Figure 2

The dolomite body in eastern Lebanon County overlying the Stonehenge Limestone and underlying the Epler Formation is made up perdominantly of laminated, very finely to finely megacrystalline, medium- and medium-light-gray dolomite, weathering yellowish (rock type B-1 of Berks County section). The remainder of the rock consists principally of nonlaminated, finely to coarsely megacrystalline, medium- and medium-dark-gray dolomite and corresponds to rock classed as rock type B-2 in the Berks County succession. As in Berks County, quartz sand and dark chert, where present, are associated with beds of rock type B-1. Quartzose and chert-bearing dolomites occur in the formation at Richland and quartzose beds occur in the exposures in Lebanon. From observation of the Richland section and of exposures in various parts of the county, dolomites of rock types B-2 are relatively numerous toward the base of the formation.

Contacts and thickness

In the study of local sections, the upper contact is placed at the base of the lowest limestone of the interbedded limestone and dolomite unit, here referred to the Epler, and occurs in the lower part of a zone of quartzose beds. For mapping purposes the top has been placed at the base of the lowest, thick, light-gray limestone bed referred to the overlying Epler and the lower contact at the top of the uppermost mappable beds of Stonehenge limestone (Gray and others, 1958; Geyer and others, 1958). The lower contact has not been set with any accuracy in the present study of exposures. Interbedded dolomites and limestones occur in the upper Stonehenge and in the lower Epler indicating that the relations of the Rickenbach with these formations are essentially transitional in Lebanon County. Transition at the top is also indicated by gradual increase in bedded dolomite downward from the Epler Formation into the Rickenbach in the Richland exposures.

PLATE 10

Figure 1.—Rickenbach Dolomite, in foreground, overlain by limestones and dolomites of the Epler Formation, at Richland, Lebanon County (section No. 14). Contact between formations placed in measured sections at base of lowest limestone bed (arrow). Gray, et al., 1958, have placed contact higher in section where limestone content of Epler is sufficient for mapping purposes.

Figure 2.—Arenaceous dolomites in the lower Epler Formation (or upper Rickenbach Formations, according to Gray, et al., 1958) at Richland, Lebanon County (section No. 14). Pencil point indicates quartzose laminae typical of these beds. Zone of quartzose beds at Richland is believed to correlate with that in the upper member of the Rickenbach in central Berks County (section No. 3).

In the Richland section, as defined and measured by the writer, the Rickenbach was determined to be at least 140 feet thick and may be as much as 470 feet thick. In this section 335 feet of exposed beds have been referred to the Rickenbach by Gray and others (1958) who have placed the upper contact higher in the section than has the writer. The formation thins westward from Richland to the City of Lebanon as indicated on the 1960 Geologic Map of Pennsylvania. As shown also on the Geologic Map of Pennsylvania, the Rickenbach is not present in the succession in western Lebanon County or in eastern Dauphin County.

Lower Beekmantown Dolomites in the Lehigh River and Delaware River Areas

Introduction

In the present study, the search for exposures of Lower Ordovician rocks in the Lehigh River and Delaware River areas has been aided by use of the geologic maps of Lehigh and Northampton Counties (B. L. Miller and others, 1939, 1941) and published information by Willard (1955). Exposures at section No. 25, along the east side of the Lehigh River in and south of Northampton, and at section No. 26 along the west bank of the river near Fullerton indicate the general nature of the succession in that area. Farther to the east, the lower part of the Beekmantown is exposed in the Delaware River Valley in Easton and to the south near Carpentersville, New Jersey. The studied sections in these areas are presented in Figure 16.

As indicated in Figure 16, correlation of the sections near the Lehigh River with those near the Delaware River is based on the highest observed occurrence of cryptozoon-bearing beds in the sections. The uppermost cryptozoon-bearing dolomites occur in the approximate middle of a succession characterized by cyclic deposits of dolomite of changing characters; and, also, they separate beds with scattered stringers of quartz sand above, from abundantly quartzose dolomites below.

General lithology and rock succession

As reported by Miller (1939, 1941) dolomite is the predominant rock type in the Beekmantown of Lehigh and Northampton Counties and increases in proportion toward the contact with underlying Allentown dolomite. A dolomite body, occurring between the cryptozoon-bearing, quartzose, and color-banded dolomites of the Allentown Formation, below, and a unit of dolomites and fossiliferous limestones, above, consists in large part of interbedded dolomites of two rock types, B-1 and B-2, both characteristic of the Rickenbach Formation in Berks County. This dolomite body, recognized in part by Willard (1955) is well exposed at Fullerton and Carpentersville (section No. 27)

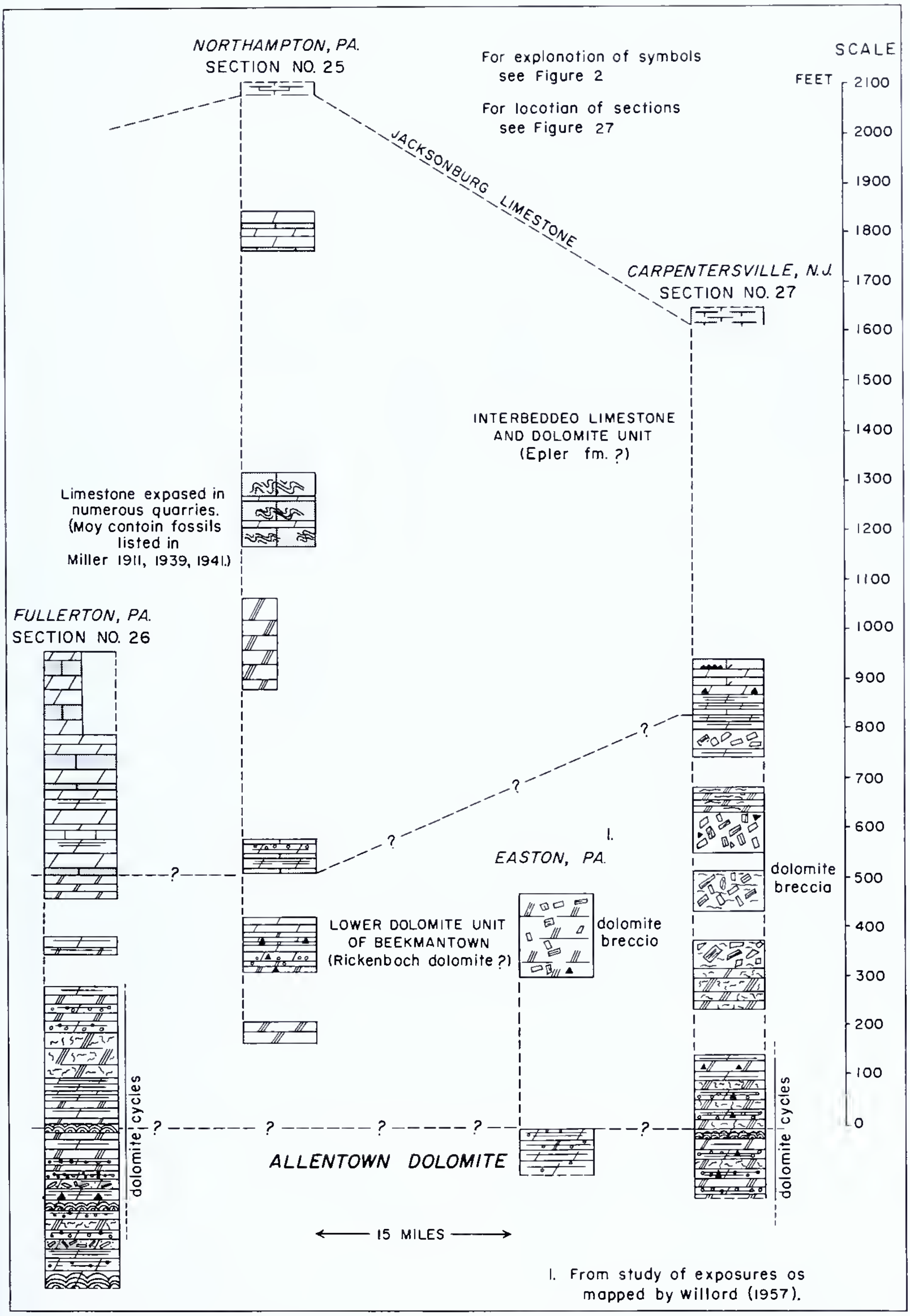

Figure 16. Preliminary Beekmantown sections in the Lehigh River and Delaware River areas.

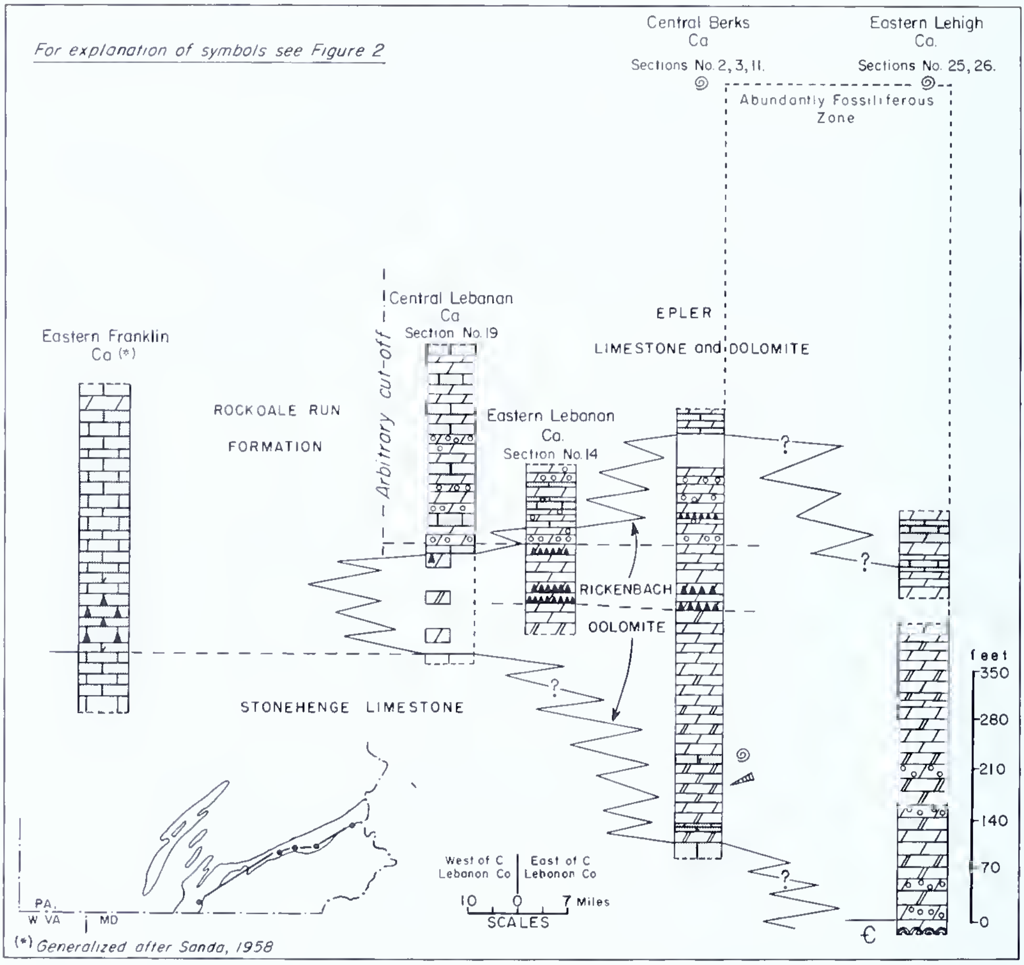

Figure 17. Stratigraphy of Rickenbach dolomite from the Lehigh River to central Lebanon County.

where it has been studied in the present investigation. At Carpentersville, 14 repetitions of laminated, very finely and finely megacrystalline, light-colored dolomite of rock type B-1 and nonlaminated, poorly bedded, finely to coarsely megacrystalline, dark-colored dolomite of rock type B-2 have been recorded. A similar succession not as well exposed occurs at Fullerton. At both localities cyclic deposits continue well into the cryptozoon-bearing Allentown dolomite.

The coarser grained dolomite is "gritty-feeling" to vuggy on a neutral-gray weathering surface and the rock is laced with gash-fracturing and micro-fractures filled with sparry dolomite. At Northampton, section No. 25, the rocks are moderately calcareous in places and contain lenses of limestone.

The finer grained dolomites characteristically possess laminae of quartz silt and of alternating shades of gray. The yellowish-weathering surface is relatively smooth, and the rock breaks with a sharp, smooth fracture under the hammer. Quartz sand and dark-chert nodules and stringers occur in several beds especially in the lower part.

Overlying the cyclic sequence at Carpentersville and exposed to the north-west in Easton are rather thick units of dolomite breccia, containing fragments that are commonly up to 1 or 2 feet across. The majority of the fragments are angular and are composed of very finely and finely megacrystalline, thinly laminated or apparently structureless dolomite weathering yellowish with a rather smooth surface. One boulder about 8 to 12 inches in diameter in the section at Carpentersville is well rounded, and subrounded fragments are not uncommon. These breccia beds have been reported previously from the Carpentersville and eastern sections by Willard (1955, 1958) who has suggested that the breccia at Carpentersville may be due to movement along faults. As a result of a study of the beds, the present writer believes that the breccia does not appear to be a fault breccia for the following reasons: (1) Some of the fragments are rounded and subrounded; (2) The breccia apparently occurs at about the same stratigraphic position at Easton and Carpentersville, sections which occur in different structural frameworks; (3) The beds of breccia appear to be interbedded with non-brecciated dolomites at Carpentersville; (4) Folds or faults are not exposed in the Carpentersville section in association with the beds of breccia; (5) Similar features on a smaller scale are found near the base of the dolomite units in central Berks County where there is also interbedding of fine and coarse dolomites; and (6) At Easton, fragments are generally concentrated along and crudely aligned subparallel to bedding; in instances at Easton where a zone of brecciated dolomite intersects bedding and borders high angle faults, the associated breccia contains fragments that are angular, very poorly sorted, and haphazardly arranged in a finely pulverized matrix.

In spite of the conclusions suggested by the internal characters and occurrence of the breccia, the thicker sequence at Carpentersville where the breccia is best developed, compared with that at Fullerton where the breccia beds are not in evidence, suggests that there may have been repetition of beds by faults at Carpentersville (see Fig. 16).

At Fullerton, the cyclic sequence is overlain by about 200 feet of dolomite of rock type B-1 with quartz sand and dark chert in the lower beds.

Contacts and thickness

The contact between the Allentown Formation and the Beekmantown has been regarded as the boundary between the Cambrian and Ordovician Systems (Willard 1955, p. 827). Although the Stonehenge Limestone is not present at the base of the Beekmantown in the Lehigh-Delaware River areas, Miller regards the relation between the Allentown and Beekmantown in the Fullerton section (Miller, 1941, p. 10) and in a section north of Chestnut Hill along the west bank of the Delaware River (Miller, 1939, p. 240) as conformable,

with the presence of transitional beds. Willard (1955, p. 831) agrees with this interpretation of the Fullerton section but cites part of the section, No. 27 of the present report, along the east bank of the Delaware River south of Carpentersville, as follows:

> "In the south wall, of the quarry, is an undulatory surface parallel to the bedding. Above it, northward, the lithology is that of the Beekmantown . . . . the Allentown-Beekmantown contact is drawn here as a disconformity." (Willard, 1955, p. 830).

Willard believes that the Beekmantown-Allentown contact changes from a disconformity in the vicinity of Carpentersville, New Jersey, along the Delaware River, to apparent conformity at Fullerton, along the Lehigh River.

The section at Carpentersville has been re-examined in some detail for the present study and is presented as section No. 27. As shown in the description of this section, there appears to be no abrupt lithologic change through the exposures. The writer did not observe physical evidence of erosion in the form of truncation of sedimentary structures or presence of an overlying basal conglomerate.

The writer agrees with Miller and Willard that the relation between the Allentown and Beekmantown in the Fullerton section is one of gradation, and in the writer's opinion, the sections at Carpentersville and Fullerton are similar in terms of distribution of dolomite rock types, of quartz sand, and of cryptozoon-bearing dolomites. The lower contact of the Beekmantown in both sections is placed rather arbitrarily at the top of the uppermost bed containing cryptozoons (Fig. 16). In both sections this bed generally separates silty-laminated dolomites above from quartzose dolomites below and occurs within a unit of dolomite rock body cycles. The contact is apparently concealed at Easton.

The relation of the upper part of the dolomite unit at the base of the Beekmantown and an overlying, poorly exposed, interbedded limestone-dolomite unit is one of gradation at Fullerton, Northampton, and Carpentersville. In the present study, the upper contact of the dolomite unit is placed at the base of the lowest limestone bed in the section.

Defined in this manner, the lower dolomite unit in the Beekmantown is about 500 feet thick at Northampton and Fullerton and about 850 feet thick at Carpentersville.

Correlation with the Beekmantown of Berks County

The dolomite body, underlying the interbedded dolomites and sparsely fossiliferous limestones that are described in the following chapter, and overlying fossiliferous Allentown dolomite of Cambrian age in the Lehigh-Delaware River

areas is tentatively correlated with the Rickenbach Formation of Berks County on the basis of similar lithology and a generally equivalent stratigraphic position. Stonehenge limestone, which underlies the Rickenbach transitionally in Berks County and westward, is not present in the sequence near the Lehigh and Delaware Rivers where the Rickenbach (?) dolomite is apparently transitional with Allentown dolomite.

Regional Changes in Thickness and Rock Character

With the possible exception of the Delaware River area where the exact succession is unknown at present, the Rickenbach Formation appears to be thickest in central Berks County where 600 feet of beds have been measured. The formation apparently thins to about one-half of this thickness in eastern Lebanon County and disappears as a mappable unit in central Lebanon County (Fig. 17). The formation is not present in the Beekmantown in eastern Franklin County.

In central Berks County, the formation has been divided into an upper member of fine-grained dolomite and a lower member of interbedded fine-grained and coarse-grained dolomite in which the proportion of the coarse-grained beds increases toward the base. Although poor exposures prevent a thorough examination of the entire formation in Lebanon County and probably equivalent beds in the Lehigh River and Delaware River areas, there is a general similarity in terms of the distribution of rock types in the respective areas in that the coarser grained rock type is proportionately greater near the base of the dolomite unit. Bedded cherts appear to be best developed where the body of finer grained dolomite is thickest, i. e. in central Berks County.

Quartzose dolomites, generally of very fine or fine crystallinity and light color, occur in all of the areas where the unit has been studied. The 90- to 110-foot zone of quartzose dolomite, entirely within the upper member of the formation in Berks County is shared by the upper Rickenbach and lower Epler Formations as defined by the writer in section in eastern Lebanon County, giving evidence of the westward increase in limestone in the general rock interval.

Regional Stratigraphy of the Epler Formation

Introduction

At the present time, the Epler Formation has been recognized in two parts of the Great Valley of Pennsylvania. In addition to central Berks County, the type area, the Epler has been mapped through Lebanon and Dauphin Counties (Gray and others, 1960), the name being applied to a limestone and dolomite unit that had previously been recognized by Gray and others (1954).

The formation may also be compared with the Rockdale Run Formation (Sando, 1957) overlying the Stonehenge Limestone in eastern Franklin County, Pennsylvania (Sando, 1958).

A body of interbedded limestone and dolomite similar to the Epler in stratigraphic position is exposed near the Lehigh River in eastern Pennsylvania. Inasmuch as beds near the Lehigh River provided the basis for recognition of Beekmantown strata east of the Susquehanna River by Miller in 1911, the rocks in that area and in the Delaware River area that are considered tentatively to correlate with the Epler of Berks County are first considered.

The studied sections are represented by generalized columnar sections in Figure 18; for more detailed columnar sections of the Lehigh River and Delaware River sequences, the reader may refer to the foregoing Figure 16.

Upper Beekmantown Limestone and Dolomite in the Lehigh River and Delaware River Areas

Introduction

Owing to the poor exposure and complex structure in the Beekmantown belt of the Lehigh and Delaware River areas, especially in the upper part of the succession, considerable detailed mapping is necessary before the succession and rock characters will be satisfactorily known. In the present study of sections, interbedded limestone and dolomite overlying dolomite similar to the Rickenbach in the Lehigh-Delaware River areas is tentatively identified as the Epler and has been studied only in the barest fashion at Fullerton, section No. 26; Northampton, section No. 25; and Carpentersville, section No. 27.

General Lithology and Rock Succession

The limestones are invariably megcrystalline, imperfectly cleaved, dolomic-mottled, and siliceous- and dolomitic-banded and weather with a shaly appearance in places. Coarsely megacrystalline patches and irregular beds resemble recrystallized calcarenite. "Edgewise" conglomerates and oolites have been reported from the limestones by Miller (1939) near the Lehigh River. The dolomites are generally finely megacrystalline, thinly laminated, and weather yellowish. The proportion of dolomite in the succession is presently unknown.

PLATE 11

Figure 1.—Folds in Beekmantown limestone and dolomite exposed in quarry near Northampton, Northampton County. Strata are believed to be coextensive with the Epler Formation of central Berks County.

Figure 2.—Boudinaged dolomite layers in limestone of the Epler Formation near Myerstown, Lebanon County. Although nearly flat lying here, strata in the area have been severely folded as shown by Gray and others, 1958.

PLATE II

Figure 1

Figure 2

Quarries near Northampton on the east side of the Lehigh River expose about 150 feet of complexly folded limestone with several thin dolomite beds (Pl. 11, Fig. 1). The lower part of the interbedded limestone and dolomite unit in the upper part of studied exposures at Fullerton is composed subequally of limestone and dolomite.

The upper part of the limestone and dolomite sequence in the Lehigh-Delaware River areas is unknown at present owing to the poor exposure in the studied sections. Dark dolomites with interbedded thin limestones are exposed about 250 stratigraphic feet below the contact with the Jacksonburg Formation at Northampton, section No. 25.

Contacts and thickness

The lower contact of the interbedded limestone and dolomite unit with a dolomite body that may be equivalent to the Rickenbach of Berks County, is placed in the studied sections at the base of the lowest limestone bed working upward from the cryptozoon-bearing dolomites of the Allentown. Owing to poor exposures, the upper contact of the unit cannot be placed at this time so that the exact thickness cannot be determined. It is not known whether the unit is in contact with the Jacksonburg Formation or whether there is an intervening mappable body of dolomite similar to the Ontelaunee Formation of Berks County. That the latter may be the case, is suggested by numerous exposures of dark dolomite bordering on the south the belt of Jacksonburg Formation in Northampton County. The Jacksonburg-Beekmantown contact in eastern Pennsylvania and New Jersey is generally considered unconformable (see Miller, 1937).

The thickness of the unit is unknown; it may be as much as 1600 feet thick near Northampton and 800 feet thick at Carpentersville.

Paleontology

Fossils appear to be rare in these beds; a list of reported fossils is given in Willard (1958). From a consideration of the general location of the collecting localities, so far as known, it is probable that many of the fossils are from beds in the upper part of the interbedded limestone and dolomite unit. Wherry (*in* Miller, 1939) identified *Liospira* sp., *Orospira* cf. *O. bigranosa* Ulrich, *Hormotoma* cf. *H. artemesia* (Billings), and *Leiostegium* sp. from a quarry south of the Hercules Cement Plant in Northampton County. Additional fossils were reported from an old quarry of the Parryville Iron Co. just south of Northampton, in quarries south of Steelton, Northampton County, and in small quarries on Schoeneck Creek east of Nazareth (Miller, 1939). All of the quarries appear to be in the predominantly limestone unit that occurs about 1200 to 1500 feet above the base of the Beekmantown at Northampton, sec-

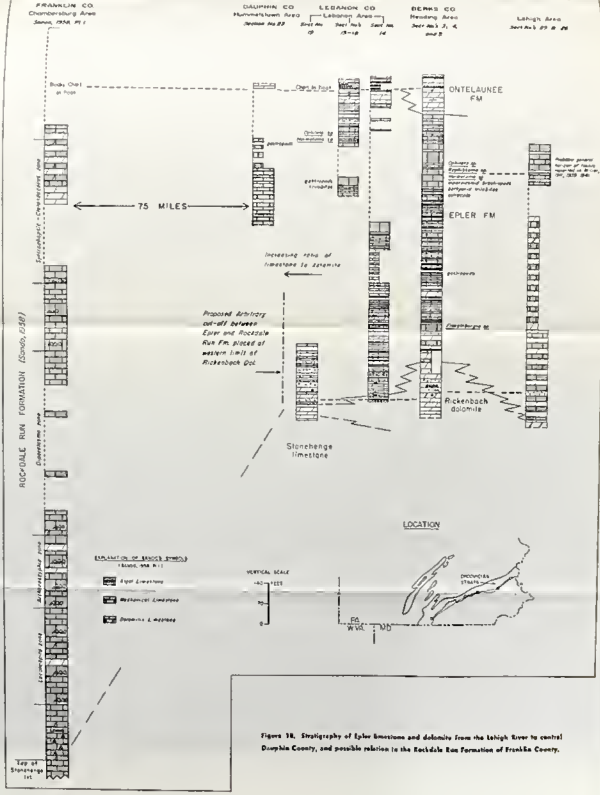

Figure 18. Stratigraphy of Epler limestone and dolomite from the Lehigh River to central Dauphin County, and possible relation to the Rockdale Run Formation of Franklin County.

tion No. 25. The relative abundance of fossils in these beds is the basis for tentative correlation with the Berks County Beekmantown, as discussed in the following section.

Correlation with the Beekmantown of Berks County.

The exposed parts of the interbedded limestone and dolomite unit described above near the Lehigh River are lithologically and paleontologically similar to the Epler Formation of central Berks County. The rocks containing many of the gastropods listed in Miller's publications and summarized by Willard (1958) are quite likely equivalent to the strata containing the gastropod and trilobite fauna in the upper part of the Epler Formation in Berks County which is located about 30 miles to the southwest. The sections in the two areas are tentatively correlated on this basis (Fig. 18).

Epler Formation in Lebanon and Dauphin Counties

Introduction

The Epler Formation has been studied in exposures at Richland, section No. 14; Myerstown, section No. 15; and Lebanon, section No. 19, as well as other small exposures in Lebanon County and at Hummelstown, section No. 23 in Dauphin County. These sections are represented by columnar sections in Figure 18. Numerous other exposures in Lebanon and Dauphin Counties were examined briefly. The Epler has been mapped through these counties (Gray and others, 1960).

General lithology and rock succession.

The lower one-half of the formation is exposed at Richland, section No. 14. The limestones are megacrystalline for the most part with dolomite mottles, sub-laminae, and sub-bands. Irregular, siliceous and silty argillaceous laminae have been thrown into asymmetrical microfolds which are generally bisected by a poorly defined rock cleavage. Rock cleavage subparalleling bedding is conspicuous in many beds, especially in the thinner limestones. Structures identified as boudinage are present in some of the interbedded limestone and dolomite sections (Pl. 11, Fig. 2). Examination of thin and etched sections from the limestones has revealed a crystalline texture with slight or no suggestion of clastic textures. For the most part, the rock lacks megascopically visible clastic textures or fossils of any kind. On the basis of these observations, it is concluded that the limestone rock types in the lower Epler of Lebanon County are somewhat dissimilar to those in the type area, chiefly because of a greater degree of metamorphism in the former area. Folds in the studied area of central Berks County are of the upright type, contrasting to the overturned and recumbent folds described in Lebanon County by Gray and others

(1958) and Geyer and others (1958). Rock cleavage is much better developed in the Beekmantown rocks of Lebanon County than in those of central Berks County. The textural appearance of Beekmantown limestones in the Lehigh-Delaware River areas resembles that in Lebanon and Dauphin Counties, indicating a similar degree of metamorphism in the two areas.

Limestones in the upper half of the formation, as exposed at Myerstown include beds of readily recognizable fragmental limestone with calcite sand, pebbles, pelmatozoan plates, and shells. Gastropod and trilobite fragments are common.

Bedded dolomite is similar in all respects to that in the type section of the formation in Berks County. Dark chert nodules and quartz sand occur in the dolomite in the lower 80 feet of the formation, as defined in this study, in the Richland section. At Lebanon about 15 feet of strata with quartzose dolomites is exposed. As a general observation, the dolomite percentage appears to be somewhat lower in the middle of the formation in eastern Lebanon County than in central Berks County. Examination of exposures along Beck, Killinger, and Bachman Creeks in central and western Lebanon County tends to confirm this conclusion.

At Hummelstown, section No. 23, upwards of 300 feet of strata, 75 percent exposed, are composed of megacrystalline recrystallized calcarenitic limestone with several thin 1- to 2-foot dolomite beds. The unit underlines Ontelaunee dolomite by a concealed interval. Beds of a similar lithology and stratigraphic position were studied in the south limb of the Steelton syncline near Highspire, western Dauphin County. In all of these exposures, dolomite is the subordinate rock type.

Contacts and thickness

The lower contact of the Epler Formation with the Rickenbach Formation in Lebanon County has been discussed previously in the chapter on the regional stratigraphy of the Rickenbach. The upper contact is placed at the base of chert-bearing dolomites that are included in the overlying Ontelaunee Formation (Gray and others, 1958 and Geyer and others, 1958). The relations between the formations are essentially transitional.

Based on exposures measured in this study, the Epler Formation is 967 feet thick at Richland, a value which is in general agreement with the reported maximum thickness of 1000 feet for the formation as defined by Gray and others (1958) in the Richland quadrangle.

The thickness of Epler in Dauphin County and western Lebanon County is unknown to the writer but is probably on the order of 1300 feet, the formation having replaced stratigraphically at least part of the Rickenbach Formation which underlies the Epler to the east.

Paleontology

The beds at Myerstown, section No. 15, about 150 feet below the top of the formation have yielded *Hormotoma* ? spp. and *Ophileta* sp. as well as numerous loosely coiled gastropods and trilobite fragments. This fossiliferous horizon is believed to correlate generally with that in the upper Epler of central Berks County and, therefore, possibly with fossiliferous limestones in the Beekmantown of the Lehigh River area (Fig. 18).

Post-Stonehenge Beekmantown Strata in Eastern Franklin County

Introduction

A composite section in eastern Franklin County including about 2100 feet of sediments overlying the Stonehenge Limestone, has been examined by A. Donaldson and the writer (technical report for The California Company, 1956). These are essentially the same exposures studied in greater detail by Sando (1958). Sando (1958) has applied the name Rockdale Run Formation (Sando, 1957) to Lower Ordovician beds overlying the Stonehenge and underlying a concealed interval in this section. Sando's description of the Franklin County exposures has been used in constructing the columnar section in Figure 18.

Knowledge of the upper part of the Beekmantown has also been obtained from the rock descriptions of Palacas (1956).

General lithology

The majority of the exposures are of dolomitic-mottled to -streaked, light-colored, smoothly fracturing limestone with clustered and scattered crystals of sparry calcite. Much of the rock is "dove-colored" (tannish gray) and weathers to a very light gray. The lithology is similar to that of the upper member of the Stonehenge in Berks County, and like the Stonehenge rock, stromatolites and lenses of fragmental limestone are characteristic. Beds of fossiliferous, fragmental limestone are numerous.

Dolomite beds, rare in the lower 2100 feet or so of the Rockdale Run Formation of Sando, increase markedly at the top of the formation. The dolomite is medium gray to medium light gray, very finely megacrystalline, weathers yellowish and is commonly laminated. The zone of interbedded limestone and dolomite is apparently about 400 feet thick. Somewhere in these upper beds is the zone of cauliflower cherts cited by Stose (1908) and Bassler (1919). The writer noted a low rise covered by angular fragments of dark chert at Marion in Franklin County which was estimated to be about 200 to 300 feet stratigraphically below the contact of the Beekmantown with the fossiliferous Row Park Limestone. Sando (1958) records abundant blocky chert in the soil from about 1667 to 2325 feet above the base of the Rockdale Run Formation. Cherts

have also been recorded by Sando from beds above the Stonehenge Limestone. The possible significance of the chert zones in correlating the eastern Franklin County sequence with the sections east of the Susquehanna River will be discussed in following sections.

Contacts and Thickness

The lower contact has been discussed in a foregoing section dealing with the Stonehenge Formation. The upper contact of the Rockdale Run is concealed in the exposures east of Chambersburg. The formation is about 2550 feet thick in the Chambersburg exposures of which the upper part is almost entirely concealed (Sando, 1958).

Paleontology

In ascending order, the following fossil zones have been reported by Sando (1958): (1) *Lecanospira* zone, (2) *Archaeoscyphia* zone, (3) *Diparelasma* zone, and (4) *Syntrophosis-Clelandoceras* zone. The zones are indicated in Figure 18.

Correlation with Lower Ordovician strata east of the Susquehanna River

The suggested correlation is indicated in Figure 18. Although equivalence of chert zones is the chief criteria, a generally similar succession of fossil types is suggested for the two areas. The following comments are from Sando (personal communication). Occurrence of *Finkelnburgia* in the lower-most Epler Formation about 600 feet above the top of the Stonehenge Limestone in Berks County may represent the *Lecanospira* zone. No evidence of the *Archaeoscyphia* zone is evident in the Berks County collection. Diparelasmoid brachiopods, abundant gastropods, numerous ostracods, and rare trilobites, including a bathyurid form, in beds near the top of the Epler Formation in Berks County, may represent part of the *Diparelasma* zone. The *Syntrophopsis-Clelandoceras* fauna does not appear to be represented in the Berks County collection.

Regional Changes in Thickness and Rock Character

As indicated in Figure 18, the Epler Formation thickens southwestward from 800 feet near the Schuylkill River to almost 1000 feet in eastern Lebanon County. Farther to the southwest in eastern Franklin County generally equivalent rocks, which include part of the Rockdale Run Formation, are on the order of 2300 feet thick.

East of Berks County the interbedded limestone and dolomite unit of the Beekmantown in the Lehigh River area appears to be about the same thickness as the Epler Formation in Berks County.

The most conspicuous lithologic difference between the post-Stonehenge rocks in Franklin County and those comprising the Epler Formation in Lebanon and Berks Counties is the greater proportion of dolomite in the latter area. Examination of many small exposures near the Lehigh River indicates a somewhat higher proportion of dolomite in the interbedded limestone and dolomite sequence of that area than in the Epler of Berks County. As shown in Figure 18, the least dolomitic part of the Lehigh River sequence may be stratigraphically equivalent to the fossilferous beds which occur in the least dolomitic upper part of the Epler in Berks County.

Accompanying the increase in the proportion of bedded dolomite in a northeasterly direction is a decrease in the amount of so-called "algal" limestone, calcilutite, and bedded pebble conglomerates and an increase in dolomitic-mottled rock in the limestone fraction. Evidence for former activity of algae, in the form of stromatolites, is common in the Rockdale Run whereas stromatolites are rare in the Epler. Bedded fragmental limestones of the type chiefly concentrated in the upper member of the Epler and in the Stonehenge Limestone in Berks and Lebanon Counties, occur throughout the Rockdale Run limestones.

Regional Stratigraphy of the Ontelaunee Formation

Introduction

At the present time, a body of dolomite with varying amounts of limestones has been recognized in the uppermost Beekmantown in two general areas of the Great Valley of Pennsylvania exclusive of central Berks County.

A dolomite unit recognized by Gray (1952a) at the top of Beekmantown of Lebanon County along with underlying dolomites and varying amounts of limestone has been mapped as the Ontlaunee Formation across Lebanon and Dauphin Counties (Gray and others, 1960). Farther to the southwest in Franklin County a body of interbedded dolomite and limestone occurs in the uppermost part of the Beekmantown (Stose, 1908; Neumann, 1951; Palacas, 1956; Sando, 1958). Sando includes these beds in the upper part of the Rockdale Run Formation of eastern Franklin County.

A mappable unit of dolomite has not been recognized to date in the Lehigh River and Delaware River areas although considerable amounts of bedded dolomite occur in exposures of the upper Beekmantown near the Lehigh River.

Ontelaunee Formation in Lebanon and Dauphin Counties

Introduction

The Ontelaunee Formation is relatively well exposed in Lebanon County. A number of sections, No's. 15-18 and 20 taken together reveal nearly the entire sequence and give some idea of the variation in thickness through the

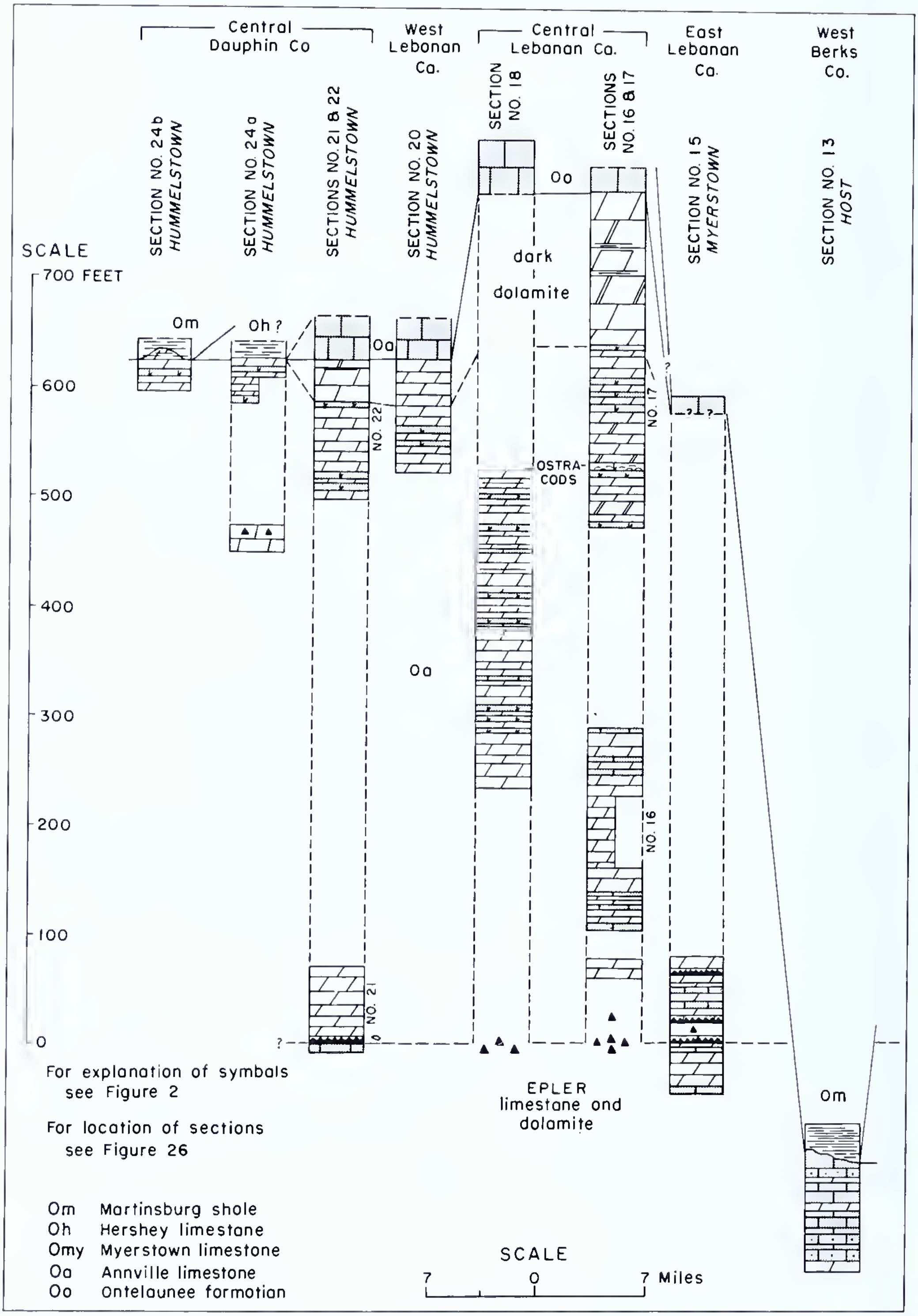

Figure 19. Correlation of sections of Ontelaunee dolomite and limestone in western Berks, Lebanon, and Dauphin Counties.

county. In Dauphin County, where exposure is poorer, the character of the Ontlaunee and the exact relations of the upper Beekmantown with overlying beds remain largely unknown at present (Section No.'s 21, 22 and 24). Prouty (1959) has discussed the contact relations between Beekmantown and overlying beds in parts of Dauphin County.

Exposures studied in the present investigation are represented by columnar sections in Figure 19.

General lithology and rock succession

In the present study of sections, three general divisions have been recognized in the Ontlaunee Formation of Lebanon County, the uppermost one of which had been recognized previously (Gray, 1952a).

The lower division of the Ontlaunee is composed in its upper part, of medium-light-gray, very finely megacrystalline dolomite with several thin, megacrystalline, dolomitic-mottled limestones. These dolomites give way downward to somewhat darker, coarser grained dolomite with dark-gray chert beds, stringers, and nodules. The lower chert zone is traceable across the county and into Dauphin County.

In Lebanon County, parts of the lower division of the Ontelaunee are exposed southwest of Myerstown at Ramona (shown only on the 15-minute topographic quadrangle), section No. 16; at Coheva, section No. 18; at Myerstown, section No. 15; and at Richland, section No. 14. The various exposures are represented in Figure 19. At Myerstown the proportion of limestone increases markedly below the cherts, indicating that the base of the lower division of the Ontelaunee is transitional with the underlying Epler. The upper contact of the division is placed at the top of a 50- to 100-foot thickness of light-colored dolomite exposed in sections No's. 16 and 18.

Overlying the lower, predominantly dolomite, division of the Ontelaunee in Lebanon County are interbedded medium- to medium-light-gray, very finely megacrystalline dolomite and smoothly fracturing, dolomitic-mottled limestone. Included in this unit are several beds of irregularly light- and dark-mottled limestone resembling beds in the lower Annville limestone. This similarity has been noted previously by Gray (1952a). One or two of the limestones are calcarenitic and contain pelmatozoan plates and rounded pebbles. At least one bed, in the upper part of the unit, contains closely packed ostracod valves. The middle division of the Ontelaunee is well exposed in the Coheva section and in the Calcite Corporation quarries north of Prescott. The unit is about 350 feet thick near Lebanon.

The uppermost division of the Ontelaunee in Lebanon County is composed entirely of medium- to dark-gray, very finely to finely megacrystalline dolomite in thick, stylolitic, sparsely laminated beds. These dolomites are completely

exposed in the Calcite Corporation quarry where they have been extensively faulted. The unit is present, typically, in every quarry where the younger Annville limestone has been quarried. A number of 2- to 4-inch layers of soft, black, carbonaceous shale are intercalated with the massive dolomite beds at Palmyra, Annville, and Prescott. The shale lacks a well-defined parting where fresh, and crumbles under slight pressure to a silty, carbonaceous powder. A loose slab of dolomite at Palmyra contains casts of what appear to be polygonal mud cracks. Particles of carbonaceous material adhere to and surround the casts indicating the "mudcracks" formed in the shale. As reported by Gray (1952a) the normal thickness of the upper division of the Ontelaunee is about 100 feet. That the unit may be somewhat thicker in central Lebanon County is indicated by the 150 to 200 feet of beds in Calcite Corporation quarry. At Palmyra, section No. 20, the unit is about 70 feet thick and south of Hummelstown, at section 22, about 40 feet thick. The unit is apparently absent in section No. 24 west of Hummelstown where shales and shaly limestones overlie dolomite and interbedded crystalline limestones believed to be Beekmantown, and is poorly developed in south Steelton near the Susquehanna River (Prouty 1959, p. 10). The uppermost Beekmantown west of Hummelstown and around Steelton is composed of interbedded limestones and dolomites, lithologically similar to the middle division of the Ontelaunee to the east in Lebanon County which contains Annville-like limestones. The similarity between Annville and Beekmantown limestones in the south limb of the Steelton syncline in the Hummelstown belt has been pointed out by Prouty (1959).

Contacts and thickness

The Ontlaunee Formation in Lebanon County, as mapped by Gray and others (1960), includes the body predominantly of dolomite that underlies the Annville Limestone and overlies the base of a prominent body of chert and cherty dolomites. The contact separating the upper, dark dolomites of the Ontelaunee from the overlying Annville is sharp. The contact is believed to be one of disconformity (Gray, 1952a, p. 3; Prouty, 1959, p. 12).

PLATE 12

Figure 1.—Unconformity between shale and Ontelaunee dolomite and limestone in exposures west of Hummelstown, Dauphin County (section No. 24a). Exposure has been pictured also by Stose and Jonas, 1927. Stose and Jonas' photograph appears to reveal truncation of beds in the dolomite.

Figure 2.—Unconformity (?) between Ontelaunee dolomite and limestone and Martinsburg shale exposed during construction along U.S. Route 422 west of Hummelstown. Exposures in Figure 1 are to observer's left at base of rise in left background. In a general manner, beds in Figs. 1 and 2 appear to dip away from each other, those in Figure 1 dipping in a northerly direction and those in Figure 2 to the south.

PLATE 12

Figure 1

Figure 2

In Dauphin County the upper contact relations are more obscure than in Lebanon County. The writer has studied two small exposures of a contact between shale and dolomite that occur in the Paxtang anticline about two miles west of the center of Hummelstown. These sections, No's. 24a and 24b are shown in Plate 12. Section No. 24a has been pictured by Stose and Jonas (1927, p. 515) who consider the contact unconformable.

In section No. 24a calcareous shale overlies dolomite containing thin limestone beds. The beds and the contact dip eastward about 10°. To the southwest of section No. 24a, gently inclined, chert-bearing crystalline limestones are exposed in a road bank and within the outcrop of the St. Paul Group as shown on the 1960 Geologic Map of Pennsylvania. These limestones appear to be stratigraphically lower than the Ontelaunee-like beds in section No. 24a on the basis of observed dips and strikes. Faults, however, are to be expected in this area and the relations may be more complex than is apparent.

A contact between dolomite and Martinsburg-like shale was recently exposed by highway construction along combined routes 422 and 322 about one-half mile west of section No. 24a. This section, No. 24b, is on the south limb of the Paxtang anticline (north limb of Steelton syncline). To the west along the north limb of the anticline a contact between Hershey limestone and Beekmantown dolomite has been interpreted as a fault contact (Prouty, 1959, p. 9). A fault contact cannot be ruled out in section No's. 24a and 24b; however, these contacts are upright and the dolomite in No. 24b strongly resembles an erosional pinnacle surrounded by shale of Martinsburg lithology. In addition, dolomite fragments have been reported from lower Hershey beds at Hummelstown and Steelton (Prouty, 1959) indicating nearby erosion as in western Berks County (Plate 5, Fig. 4). Hence an unconformity, possibly of more local importance as compared to that in the Reading area, is shown in Figure 19. It seems particularly interesting that the dolomite and limestone immediately beneath the shale in section No. 24a strongly resemble that of the middle division of the Ontelaunee in Lebanon County.

The lower contact of the Ontelaunee with the Epler Formation is believed to be transitional and is exposed at Myerstown, section No. 15.

As defined in Lebanon County, the Ontelaunee Formation in measured sections is at least 750 feet thick where most fully developed. As shown in Figures 19 and 20, there is indication that the formation thins to the southwest into Dauphin County and to the northeast from the center of Lebanon County and that the amount of thinning is approximately equal to the thickness of the upper dolomite division which, as indicated previously, thins to the southwest and apparently disappears in parts of central Dauphin County.

Changes in Lithology and Thickness from Central Berks County to the Susquehanna River

Figure 20 shows, in generalized fashion, regional stratigraphic relations of the Ontelaunee Formation.

The lower and middle dolomite members of the Ontelaunee in central Berks County are replaced by a succession of dolomite and limestone in Lebanon County to the southwest. The fact that the Ontelaunee becomes more limy to the southwest should be considered when dealing with the relations between upper Beekmantown and younger strata in Dauphin County. The upper member in central Berks County appears to be represented by a unit to the southwest (middle division in Lebanon County) that contains about twice the thickness of limestone. As previously mentioned, this limestone in the Ontlaunee is somewhat similar to "Stones River" and Annville rock types.

The following observations indicate that the dark dolomites comprising the upper division of the Ontelaunee may be younger than the uppermost Ontelaunee of central Berks County: (1) There is no suggestion of interfinger- of light- and dark-colored dolomites in the upper Ontelaunee of central Berks County; (2) The interbedded limestone and dolomite unit underlying the upper dolomite in Lebanon County is lithologically similar to the upper member in Berks County; (3) Assuming that the rates of dolomite formation were the same in the two areas and that the lower chert beds in each of the areas are essentially contemporaneous, the greater thickness of Ontelaunee in Lebanon County over that above the lower cherts in Berks County, a value of about 200 feet, indicates that the upper dolomite in Lebanon County may be younger than the uppermost Ontelaunee in central Berks County.

In summary it appears that the Ontelaunee Formation is represented by a more limy facies in Lebanon and Dauphin Counties than in central Berks County, and that the more limy facies is overlain by a dark, carbonaceous dolomite unit apparently having no extension or equivalent in the central Berks County sequence.

Post-Ontelaunee Unconformity Between the Susquehanna and Schuylkill Rivers

Unconformable contacts between the Ontelaunee Formation and the Jacksonburg Formation and Martinsburg Formation have been described from central Berks County in a foregoing section. There is considerable reason to suppose that similar contacts occur in parts of central Dauphin County (section No. 24) although absence of beds in the northern limb of the Paxtang anticline between Harrisburg and Hummelstown generally has been attributed to fault-

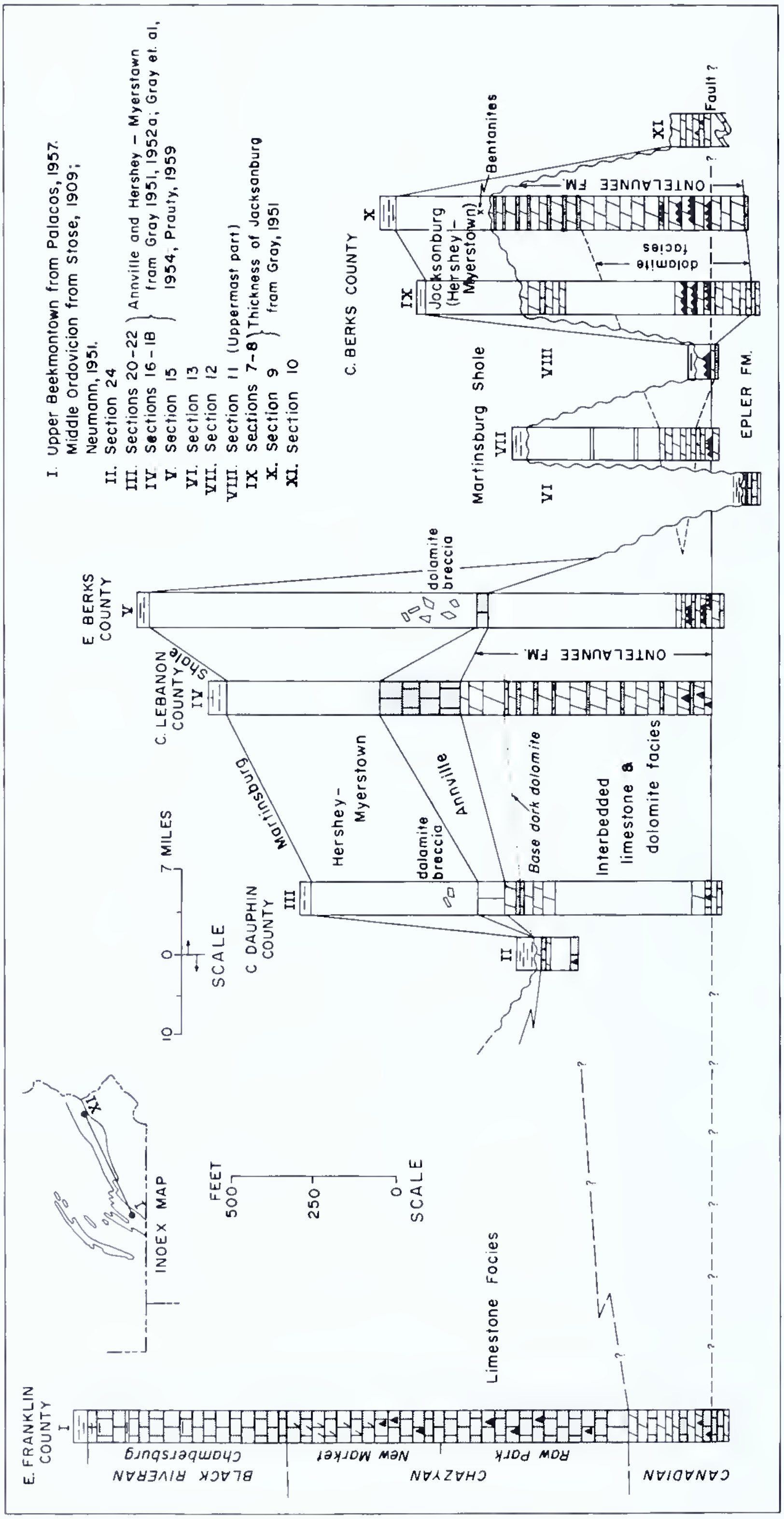

Figure 20.

Stratigraphy of the Ontelaunee Formation through Berks, Lebanon, and Dauphin Counties and tentative correlation with uppermost Beekmantown and Middle Ordovician beds in southern Pennsylvania.

ing (Stose and Jonas, 1927; Prouty, 1959; Gray and others, 1960). The contact between the Annville Limestone and the Ontlaunee Dolomite is also considered to be one of disconformity (Gray, 1952a, p. 3; Prouty, 1959, p. 12).

As will be presented in a later section dealing with Beekmantown tectonics, the writer believes that the unconformable contacts between the Beekmantown and Jacksonburg and the Beekmantown and Martinsburg are genetically related and represent, essentially, a single unconformable surface. This surface is indicated in Figure 20.

Possible Relations of the Ontelaunee Formation East of the Susquehanna River and the Upper Beekmantown and Middle Ordovician Beds in Franklin County

As mentioned previously in a treatment of the regional stratigraphy of the Epler Formation, a unit composed in large part of dolomite occurs at the top of the Beekmantown underlying the Row Park Limestone in Franklin County. This unit, partially included in the Rockdale Run Formation by Sando (1958), apparently contains the prominent zone of chert mentioned by Stose (1908) and Bassler (1919). Sando also recorded an occurrence of blocky chert float in his section descriptions and the present writer noted a low rise near Marion which was covered by angular blocks of dark chert. The top of the chert described by Sando is about 222 feet below the Row Park Limestone; that observed by the writer was estimated to be between 200-300 feet below the Row Park. The cherts, therefore, occur within a unit of interbedded limestones and dolomites similar in lithology and stratigraphic position to the Ontelaunee Formation of Lebanon County. A reconnaissance of the Carlisle quadrangle, located between the Susquehanna River and Franklin County and mapped by Stose (1953), revealed the existence of dolomites in the upper Beekmantown of that area. Cherts were not found, however. Inasmuch as the dolomite unit appears to be traceable into Franklin County from Dauphin County and contains dolomite, chert, and limestone similar to that of the Ontelaunee in the area from Dauphin County northeastward to central Berks County, the upper Beekmantown of eastern Franklin County is correlated with the lower part of the Ontelaunee Dolomite (Fig. 20).

If this correlation is correct and if the contact between the Beekmantown and the Row Park Limestone in eastern Franklin County is essentially transitional as suggested by Palacas (1956), it is reasonable to advance the hypothesis that the Ontelaunee Formation in Berks and Lebanon Counties may be partially a dolomitic facies of the lower Chazy limestones in Franklin County. That this may be the case is also indicated by the following: (1) occurrence of pure limestones in the upper Ontlaunee of Berks County and the apparently time-

equivalent middle Ontlaunee of Lebanon County; (2) increase in proportion and thickness of these limestones southwestward into Dauphin County; (3) occurrence of a gastropod resembling *Maclurites magnus* in a limestone boulder near the Beekmantown-Martinsburg contact in central Berks County in the present study; and (4) a tentative age of upper Chazy or lower Black River for the overlying Annville, and the identification of possible middle "Stones River" beds overlying the Ontelaunee in the north limb of the Steelton syncline (Prouty, 1959).

If the middle Ontelaunee of Lebanon County is equivalent to the lower "Stones River" west of the Susquehanna, at least in part, the time significance of the Annville-Beekmantown unconformity is considerably reduced. Recently, Willard (1958) has proposed that the old name Coplay Limestone (Wherry, 1909) be reinstated in the Lehigh Valley because of the suspected Middle Ordovician age for the upper part of the section commonly mapped as Beekmantown.

Stratigraphic Framework of Beekmantown Rocks from the Delaware River, Eastern Pennsylvania, to Franklin County, Southern Pennsylvania

Introduction

The stratigraphic diagram of Figure 21 represents an integration of previously presented data derived from study of the regional changes of the respective formations and of strata that are generally time equivalent to them. The diagram reveals in graphic form the interfingering and unconformable relations of the formations. Owing to the distribution of studied outcrops the direction in which the framework has been studied lies in a generally northeast-southwest striking plane. Figure 21 is meant to show mainly the relations of the mappable rock bodies in the framework; a succeeding discussion is concerned more directly with the distribution and interpretation of facies in the framework.

Distribution of Cherts and Quartzose Beds in the Stratigraphic Framework

As has been shown in the discussion of the respective formations, zones of chert occur at two levels in the Beekmantown of Berks and Lebanon Counties. The chert zones maintain a generally similar position with respect to the top and bottom of the Beekmantown as a whole and are separated by an almost constant interval of stratigraphic thickness through Berks and Lebanon Counties (Fig. 21). Quartzose dolomites are associated with the lower zone.

In central Berks County the base of the upper chert zone is about 1150 feet above the base of the lower chert zone and about 1072 feet above the base of the arenaceous zone. In eastern Lebanon County, at section No. 14, the base of the upper zone is about 1182 feet above the base of the lower chert zone and about 1065 feet above the base of the zone of quartz sand. In central Berks County the quartzose zone is about 109 feet thick and in eastern Lebanon County it is about 91 feet thick. The stratigraphic equivalence of the cherty and arenaceous zones in central Berks and eastern Lebanon Counties, therefore, is based on the fact that the stratigraphic intervals between the bottoms of the zones are essentially the same in the two areas as well as the fact that they occur in the same general stratigraphic position. In addition, the upper and lower cherty zones have been mapped through central Berks County (Hobson, 1958) and the upper zone has been mapped through Lebanon County as well (Gray and others, 1958; Geyer and others, 1958). The upper cherty zone may also be represented in central Dauphin County as section No. 21. As previously indicated in the chapters on the regional stratigraphy of the Epler and Ontelaunee Formations, a zone of chert occurs in the Chambersburg area at a similar position and in association with dolomite of a similar lithology as the upper chert northeast of the Susquehanna River.

In addition to their value as mappable rock units, the zones of cherty dolomites are believed to be essentially time-parallel through Berks and Lebanon Counties and, in the case of the upper chert, through Dauphin County, for the following reasons: (1) Inasmuch as the cherts parallel planes of stratification, show evidence of penecontemporaneous brecciation, and occur in zones of regional extent which show evidence of normal stratigraphic thinning, the cherts are considered to be early in origin and the result of sedimentary process; and (2) the bases of the two chert zones parallel one another and a zone of detrital quartz without regard to changes in the limestone-dolomite ratio.

The two chert zones in the Chambersburg region are thought to be generally correlative to those in Berks and Lebanon Counties, mainly because they occur in similar stratigraphic positions, the interval between them being somewhat greater in Franklin County owing to a faster rate of deposition in that area. The positions of the cherts in the two areas appear also to bear the same stratigraphic relation to a somewhat comparable sequence of faunas.

Regional Changes in Thickness and Limestone-Dolomite Ratio

As shown in Figure 21, the Beekmantown undergoes a general thickening from the Delaware River southwestward to eastern Franklin County. Accompanying the thickening of the sequence, there is an increase in the proportion of limestone to dolomite in all parts of the succession. As indicated in the

discussion of the regional stratigraphy of the Stonehenge Limestone, a similar change in the proportion of limestone to dolomite is evident in the underlying Cambrian strata.

That the change in the limestone-dolomite ratio is gradual and occurs by normal change in facies is indicated by the following observations: (1) a gradual thinning and disappearance of the Rickenbach Formation and the increasing amount of limestone in the Ontelaunee from central Berks County southwestward, (2) the appearance of limestones in the upper unit of cherty dolomites in western Berks County and throughout Lebanon County, and in the lower cherty and arenaceous dolomites in eastern and central Lebanon County, (3) the vertically transitional nature of the limestone and dolomite bodies in the Beekmantown throughout the region, (4) an increasingly limey nature of the middle part of the Epler Formation from the Lehigh River southwestward to Dauphin County, and (5) the occurrence in the Rockdale Run Formation in Franklin County of dolomite similar in all respects to that in the Beekmantown northeast of the Susquehanna and the gradual increase in dolomites at the top of the exposed Rockdale Run Formation.

As discussed in the section dealing with regional stratigraphy of the Ontelaunee Formation, it is possible that part of the Ontelaunee may be the dolomitic time equivalent of part of the Chazy-age limestones of Franklin County. This interpretation is incorporated in Figure 21. It is especially possible that the middle and (or) the upper divisions of the Ontlaunee in Lebanon County are lower Chazy in age. If the middle part of the Ontelaunee in Lebanon County is lower Chazy, then the generally equivalent upper member in Berks County may be partially of Chazy age.

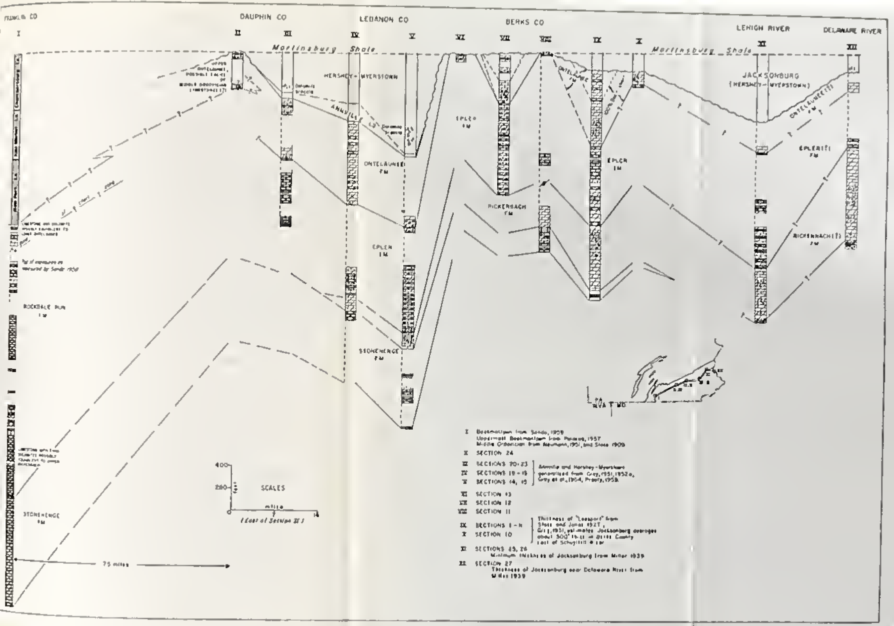

Figure 21.

Stratigraphic framework of the Beekmantown Group from Delaware River, eastern Pennsylvania, to eastern Franklin County, southern Pennsylvania.

DISTRIBUTION AND INTERPRETATION OF LITHOFACIES TYPES AND SUBTYPES

Introduction

This chapter is concerned with the distribution and interpretation of lithofacies within the Beekmantown from the Lehigh River and Delaware River areas southwestward to eastern Franklin County.

Correlation and comparison of the various local rock successions of the Beekmantown have made it possible to construct the two-dimensional stratigraphic framework presented in a foregoing chapter. Integration of petrologic and paleontologic data with the framework reveals the distribution and intergradation of rocks of different aspect, as well as shifts of the loci of deposition through time and space.

In order to be more definitive and to avoid unnecessary ambiguity in the following discussion, it will be well to define the terms lithofacies and lithofacies type as used by the writer. In this paper, lithofacies is essentially synonymous with rock aspect, whereas lithofacies type and subtype apply to rock masses of certain aspects in the same manner that rock type applies to rocks of a certain lithology. As used in this paper, then, a lithofacies type is a group of strata that possesses a similar rock aspect or lithofacies and that undergoes a demonstratable lateral gradation into rocks of a different aspect. These groups of strata are composed in most cases of a number of rock types and subtypes.

Lithofacies Types and Subtypes: Their Regional and Cyclic Relations and Interpretation

Lithofacies Types and Subtypes

The following lithofacies types and subtypes have been recognized by the writer in the Beekmantown of the Great Valley in Pennsylvania.

Lithofacies type No. 1—Limestone (less than 5 percent of bedded dolomite)
- Lithofacies subtype No. 1a—Fragmental, bioclastic limestone
- No. 1b—Nonfragmental, algal limestone
- No. 1c—Nonfragmental (?), "lime-mud" limestone

Lithofacies type No. 2—Dolomite (less than 5 percent of bedded limestone)
- Lithofacies subtype No. 2a—Very finely megacrystalline, lighter colored dolomite
- No. 2b—Medium megacrystalline, darker colored dolomite

Lithofacies type No. 3—Interbedded limestone and dolomite

Lithofacies subtype No. 3a—Interbedded limestone and very finely megacrystalline dolomite

No. 3b—Interbedded limestone, very finely megracrystalline dolomite, and medium megacrystalline dolomite

No. 3c—Interbedded very finely megacrystalline dolomite and medium megacrystalline dolomite

The essential characteristics of rock included in the respective lithofacies subtypes are given in Table 6. Detailed petrography of rock types is given in Appendix I.

Geographic Distribution and Interpretation of Lithofacies Subtypes

A stratigraphic diagram showing the observed and inferred distribution of rock of different lithofacies is given in Figure 22. The illustration differs from Figure 21 which shows the distribution of the formations and which is less inferential.

The distribution of lithofacies subtypes from southwest to northeast in any given time-rock unit appears to be as follows: (1) nonfragmental, algal and calcilutitic limestone, (2) fragmental, bioclastic limestone, (3) interbedded limestone of the above lithofacies and very finely megacrystalline, light-colored dolomite or interbedded very finely megacrystalline, light-colored dolomite and medium megacrystalline, dark-colored dolomite, and (4) very finely megacrystalline, light-colored dolomite.

Dolomite rock, where laterally gradational with limestone strata, has been thought of as a nearshore lithofacies type and the limestone an offshore, deeper water sediment (Lesley, 1879; Ulrich and Schuchert, 1902; Dixson, 1907; VanTuyl, 1918; Sloss, 1947; Cloud and Barnes 1948; Rittenhouse, 1949; Krynine, 1957). It has been stated as a general rule that marine dolomites are epicontinental shelf and shallow geosynclinal sediments and never represent bathyal or abyssal conditions (Fairbridge, 1957, p. 1954). Stromatolites, mudcracks, ripple marks, flat-pebble conglomerates, cross-bedding, broken and abraded bioclastics, and diastemic surfaces associated with one or another of the Beekmantown rock types indicate that the Beekmantown rocks were deposited in the shallow neritic to littoral zones rather than in the deeper neritic, bathyal, or abyssal environments.

As indicated in Table 6, two general types of dolomite have been distinguished in the present study similar to those described by Krynine (1957). It is believed that each of these had a distinctive mode and time of origin. It is proposed that the first of these types described in Table 6, the very finely megacrystalline, light-colored, typically laminated dolomite is the result of a

Table 6. *Summary of rock characteristics of lithofaces subtypes in the Beekmantown Group of the Great Valley of Pennsylvania.*

FRAGMENTAL, BIOCLASTIC LIMESTONE:

Includes rock bodies composed in large part of clastic calcite grains which include fragments, sand, "pellets", bioclastics; pelmatozoan plates and gastropod and trilobite shells most common, few brachiopods in rock of this aspect in Berks and Lebanon Counties, ostracodes fairly common in some beds of Epler limestone in Berks County; cross-bedding, mudcracks, and siliceous laminae and mottles are common; cyclic deposits similar to those described in the Stonehenge of Berks County are characteristic as are beds of "edgewise" and flat-pebble conglomerate; proportion of the mineral dolomite usually quite low although dolomite mottles are common in some beds; includes rock of the following subtype: B-4a B-5a, B-6a, B-6b, and B-3d.

NONFRAGMENTAL, ALGAL LIMESTONE:

Includes massive-bedded rock bodies composed mostly of microcrystalline and submicrocrystalline calcite with scattered lenses of fragmental limestone; rock bodies are massive bedded with poorly defined stratification; includes bodies with stromatolites and "channels" filled with calcite sand and bioclastics are common; in addition to pelmatozoan plates and trilobites, brachiopods are abundant; gastropods appear to be rare in the rock of this aspect in Berks County; includes rock of subtype B-3c (rock of subtype B-5b in "channels"). In his Chambersburg section, Sando (1958) places all limestone not classed as "mechanical" into an "algal" category.

NONFRAGMENTAL LIME MUD:

Includes generally thin-bedded rock bodies composed of microcrystalline and submicrocrystalline calcite and lacking evidence of algal activity in the form of stromatolites; clastic lenses are common; pelmatozoan plates, trilobites, brachiopods, and gastropods are equally common in rock of this aspect in Berks County where rock occurs only as interbeds with dolomite, hence included in facies 3a; common in the sequence in eastern Franklin County; includes rock of type B-3.

VERY FINELY MEGACRYSTALLINE DOLOMITE:

Includes rock bodies composed of finely megacrystalline to microcrystalline dolomite that are typically laminated but are also apparently structureless and mottled; laminae are typically transected by "arborescent" structures; fresh color is light shades of gray; weathered color yellowish; pyrite and limonite common; negligible effervescence in cold, dilute HCl; barren; contains no evidence of replacement or relict textures; well bedded; also occurs interbedded in cyclic deposits with limestones; includes rock of subtype B-1a, B-1b, B-1e, B-1f, B-1g, and B-1h.

MEDIUM-MEGACRYSTALLINE DOLOMITE:

Includes rock bodies composed of medium- and coarsely crystalline dolomite that are typically structureless; fresh color is darker shades of gray than dolomite above; weathering color neutral gray on "gritty" to vuggy surfaces; reaction with cold, dilute HCl; relict textures and fossils common; some incompletely replaced limestone with marine fossils; also occurs in cycles with finer grained dolomite; includes rock of type B-2.

dolomite-producing depositional environment and, whether by direct inorganic precipitation or by replacement, the dolomite formed essentially on the sea floor. The absence of fossils is more plausibly attributed to initial absence of life than to complete destruction of organic remains by dolomitization. The appreciable content of pyrite indicates a reducing environment in the sediment, a condition which, in combination with a high salinity, may have inhibited life on the sea floor. The thin laminae of the dolomite rock suggest quiet conditions; occasional mild disturbance and possible erosion is indicated by small diastems, cross-bedding, and slump structures. The escape of gases and fluids is recorded by the "arborescent" structures described in dolomites of this rock type (B-1) in the Beekmantown of Berks County.

These dolomites, here termed "earlier" dolomites (Krynine, personal communication), are believed to represent a semi-restricted, possibly near-shore, environment of formation. In the writer's concept, these loci are coalescing "pans" situated close to a low source land or a group of low islands and filled with shallow, quiet, and warm marine waters in which salts, particularly those of magnesium, are supplied by inflow over seaward barriers and are concentrated by evaporation. The concept is patterned after that originated by Ochsenius in 1877 (in Kuenen, 1950, p. 46) to explain the concentration of salts in a part of the Caspian Sea.

As discussed in a previous section, the proportion of bedded dolomite classed as "earlier" dolomite increases in a northerly direction from Franklin County to central Berks County. Associated with the overall increase in bedded dolomite, two mappable bodies of "earlier" dolomite show a northeastward thickening. That the direction of increase in proportion of bedded dolomites bears some shoreward component is indicated by the relation of the direction of increasing dolomite to the early Ordovician unconformity which has been partially described in foregoing sections. The unconformity, apparently not present in eastern Franklin County, is of considerable importance northeastward from the Susquehanna River. Localized Martinsburg-Cambrian contacts in Lebanon and Berks Counties and northeastward to the Delaware River (Stose and Jonas, 1927) with only scattered and relatively thin beds of erosional conglomerate in the Jacksonburg east of western Berks County to the Delaware River argues for the existence of emerged land in parts of that area during Beekmantown time. Therefore, it is plausible to suppose, both from the internal "shallow-water" evidence in the "earlier" dolomites and from their relation to the unconformity, that the Berks County-Delaware River area, where the "earlier" dolomites are best developed, was closer to land than was the Chambersburg region during the time of their formation and that the locus for "earlier" dolomite formation was nearer to shore than was that for the limestones.

Bedded cherts are best developed near the base of the "earlier" dolomite bodies in the Rickenbach and in interbedded "earlier" and "later" dolomites in the Ontelaunee in Berks County. The chert zones decrease in thickness and the proportion of chert in the zone lessens in a southwestward direction where they become associated with lithofacies subtypes 3a and in the lower Epler Formation and with lithofacies subtype 3b in the Ontelaunee Formation. The thickening of the upper chert zone from eastern Franklin County northeastward to the Schuylkill River and the thickening of the lower chert zone from Lebanon County northeastward to the Schuylkill may indicate the general direction of the source of the silica which conceivably might have been a deeply weathered source area or a volcanic region. In general, the cherts appear to be best developed in the offlap portions of the "earlier" dolomite bodies (Fig. 23).

In contrast to the "earlier" dolomites are the medium megacrystalline dolomites described in Table 6 and in the discussion of the Petrology of the Beekmantown in Berks County. As indicated in the discussion of the regional stratigraphy of the Rickenbach and Ontelaunee Formations and in Figures 22 and 23 the coarser grained dolomites occur most commonly as interbeds with "earlier" dolomites in lithofacies subtype 3c or with limestones and "earlier" dolomites in lithofacies subtype 3b and generally occur beneath a body of "earlier" dolomite. Furthermore, the thickness of rock of lithofacies 3c appears to vary proportionately with the thickness of the overlying body of "earlier" dolomite and the rock bodies of both lithofacies thin from the Schuylkill River southwestward.

The megascopic and microscopic study of medium megacrystalline dolomites of rock type B-2 presents considerable evidence, summarized in Table 6, that these dolomites are the result of post-depositional replacement of marine limestones. In view of this, these dolomites have been termed "later" dolomites (Krynine, personal communication). In the depositional sense, the "later" dolomites are treated as limestones and the interbedded "earlier" and "later" dolomites, lithofacies subtypes B-3b and B-3c, are regarded as interbedded limestone and "earlier" dolomite in the stratigraphic framework.

It has been suggested by Krynine (1957) that the "later" dolomite beds may have resulted from downward percolation of Mg-bearing solutions from the overlying locus of "earlier" dolomite formation, dolomitizing the partially consolidated, underlying limestone bed. Inasmuch as the body characterized by "later" dolomites is confined beneath a considerable thickness of "earlier" dolomite in both the Rickenbach and Ontelaunee Formations in the stratigraphic framework, there is indication that the replacement took place in the Beekmantown of the study area only where there was continued formation of "earlier" dolomite for a period of time.

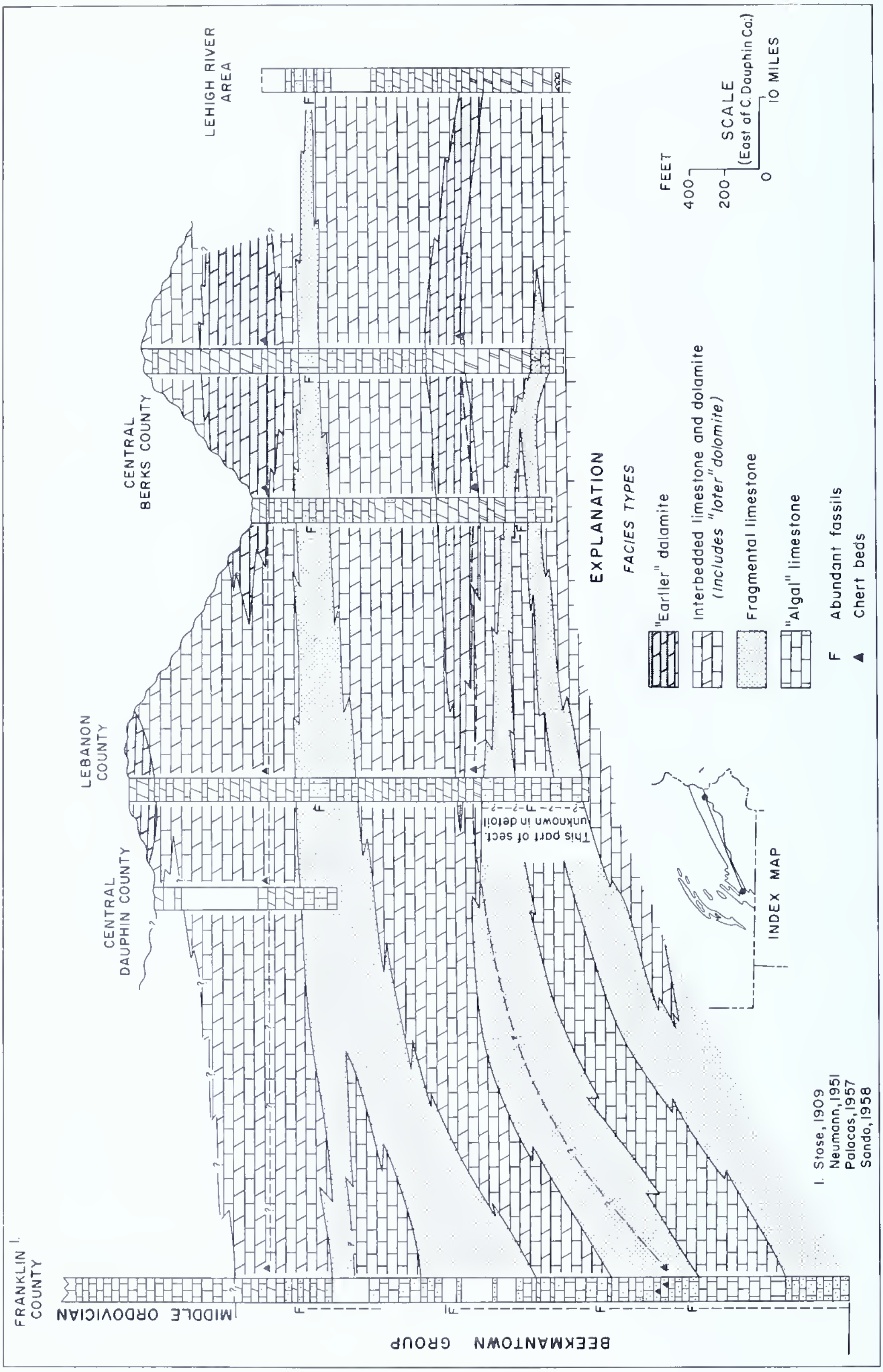

Figure 22. Generalized distribution of facies types in the Beekmantown Group of central Berks County.

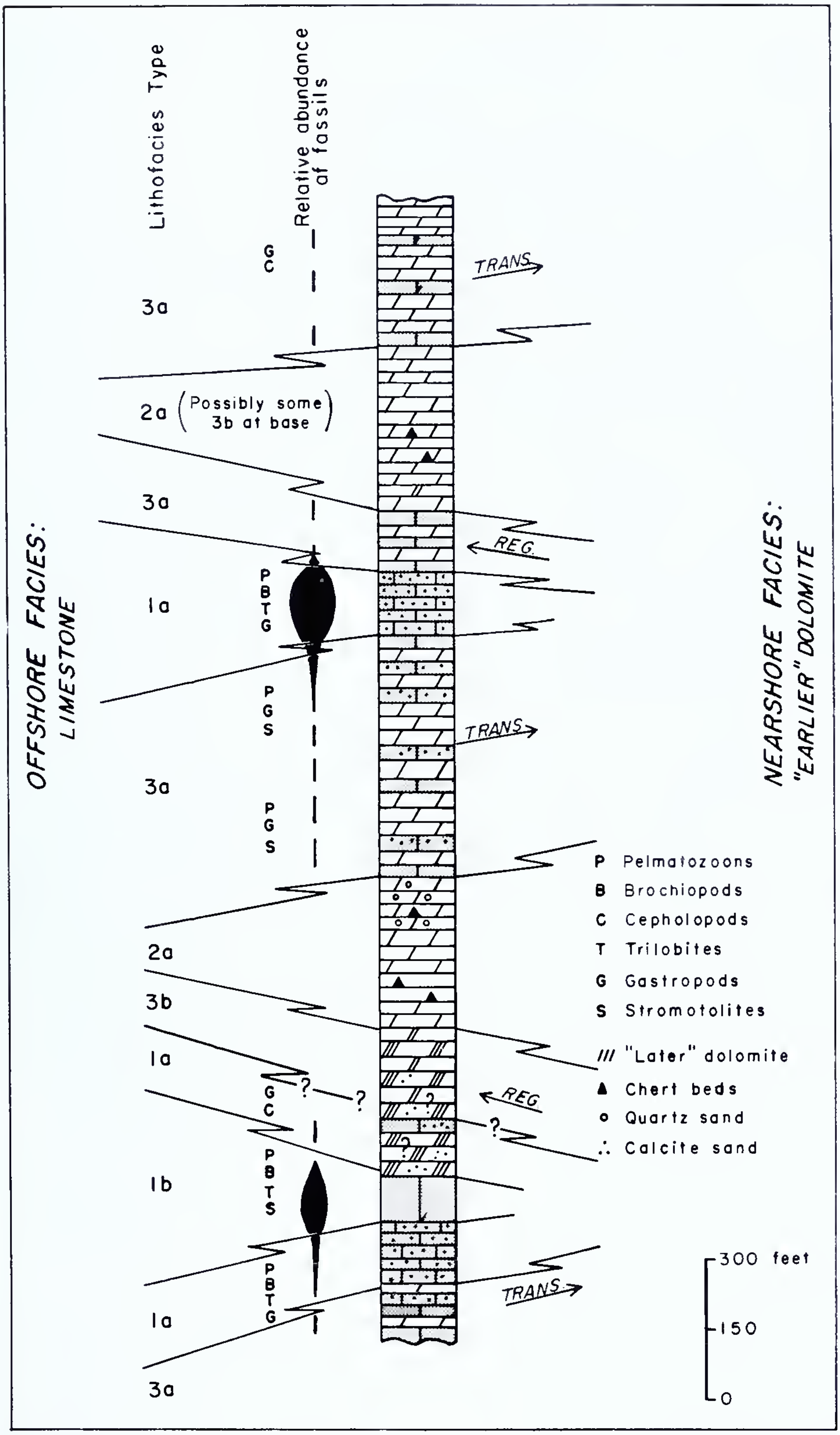

Figure 23. Cyclic relations of facies types in the Beekmantown Group of central Berks County.

Bioclastic, fragmental limestones, studied microscopically in samples of the Stonehenge and the Epler of Berks County and described summarily in Table 6, occur typically in repetitious deposits with siliceous-laminated and silty-cross-bedded calcisiltite and siliceous-mottled calcilutite. The characteristics of these repetitions, as studied principally in the Stonehenge of Berks County, are summarized as follows: (1) The typical complete cycle is composed of flat-pebble conglomerate at the base, overlain by siliceous-mottled, sandy calcilutite which in turn is overlain by siliceous-laminated and silty-cross-bedded calcisiltite or silty calcarenite; (2) The fragments, generally composed of calcisiltite, are platy and usually of subequal length and breadth; (3) The cycles are associated with mud-cracked bedding surfaces; (4) The cyclic deposits contain numerous pelmatozoans, gastropods, and trilobites; brachiopods appear to be relatively rare in the cycles in Berks County; (5) The cycles, where they are best developed, are characterized by a low content of bedded dolomite; and (6) "Fucoids" are common on the bedding surfaces of the cyclic deposits. Cross-beds of quartz silt, mudcracks, and clastic textures and fabrics in the cycles are evidence for the former existence of shallow waters in the range of wave base and current action and of periodic emergence. The abundance of crinoids, which are exclusively marine in modern seas (Bather, 1928), and the general absence of bedded dolomite indicate water of normal marine salinity. The cyclic relations of the rock types suggest succeeding periods of (1) quiescence accompanied by slumping of soft muds and local scouring (sandy calcilutite), (2) strong current acitivity with influx of quartz silt and sand and detrital micas (calcisiltite), and (3) more vigorous wave and current action which may have followed mud flat conditions (flat-pebble conglomerates). Consideration of the stratigraphic framework (Fig. 22) indicates that the fragmental limestone locus apparently was seaward with respect to the earlier dolomite locus of formation. It is plausible that the fragmental limestones may represent the deposits on a shallowed area. Such a topographic high would partially block the landward areas as well as provide a shallow-water environment for the production of the clastic features of the rock. Mudcracks on extensive bedding surfaces indicate that the barrier was periodically and locally emergent, blocking at least partially the inflow of marine waters into the more saline locus of dolomite formation. Lithofacies type 3 may represent a locus of deposition intermediate between the clastic and the dolomite-forming loci. It is interesting to note that semi-fragmental limestones, generally containing an exclusively gastropod fauna, are relatively abundant in limestones of the interbedded limestone and dolomite strata of the transgressive stages of the Epler and Ontelaunee Formations in Berks County. Conceivably, formation of these relatively pure, light-colored lime muds that are largely free of detritus

may be due to periodic influxes of normal marine waters over the seaward barrier during the transgressive stages, thereby giving rise to dilution in the "pan" and preventing continued formation of dolomite.

Thick bodies of lithified "lime mud" and of algal limestones are characteristic of the Beekmantown in the Chambersburg area. The characteristics of these lithofacies subtypes are summarized in Table 6. The algal limestones, in addition to their content of stromatolites, contain dikes and lenses filled with calcite sand which truncate the obscure, styolitic bedding of the rock. These features have been studied in the upper member of the Stonehenge in central Berks County. It is tentatively concluded from petrographic and stratigraphic study that the calcarenite that fills the channel-like structures was derived from the enclosing calcilutite. The calcilutite may have formed in part by organic fixation of calcite and in part by inorganic precipitation of calcium carbonate aided by the utilization of CO_2 by algae. The thickness, about 60 feet, and the apparently restricted areal distribution of the unit suggest a reef-like mound. The abundance of invertebrate remains, stromatolites, indistinct bedding, massive appearance, and the small percentage of detritals strengthens the reef hypothesis. The abundance of pelmatozoan plates and brachiopod valves indicates that the waters were probably of normal marine salinity. Algae would require shallow waters within the photic zone so that they might carry on photosynthetic activity. Irregular channels, similar in morphology to the channel-like structures in the upper member of the Stonehenge in central Berks County, have been reported from the Bahamas in the reef platforms under 4 to 5 fathoms of water (Newell and Rigby, 1957). The channels contain non-oolitic calcareous sand in transit to the deeper waters beyond the marginal escarpments.

The associated lime muds, lithofacies subtype 1c, in south central Pennsylvania may have resulted from precipitation of lime through organic or inorganic agencies or by accumulation of finely comminuted material.

As indicated by their position in the stratigraphic framework (Fig. 22) lithofacies subtypes 1b and 1c are characteristic of the thickened sequence and they may represent algal growth on the seaward side of the shallowed bank accompanied by deeper water accumulation of lime mud. In addition to pelmatozoans and trilobites, brachiopods are associated with the algal facies in Berks County. Gastropods appear to be relatively rare.

Cyclic Relations of Lithofacies Subtypes

Repeated tangential shifting of the sedimentary loci described above has resulted in a rhythmic offlap-onlap sequence of lithofacies subtypes, causing cyclic sedimentary deposits in a given area. As nearly all of the lithofacies subtypes are present in the Berks County sequence, which has been examined in

the greatest detail, the cyclic relations are described from this area. Figure 23 illustrates the vertical relations of the subtypes in central Berks County. The onlap and offlap relations shown in the illustration are based on the interpretation that the dolomite is a nearshore deposit.

Beekmantown and Lower-Middle Ordovician Tectonics

Paleotectonic Controls of Sedimentation

It is difficult to evaluate the relative importance of climate and large-scale earth movements in producing the rock types and the shifts in lithofacies types in a carbonate sequence. For instance, the development and gradual lateral extension of the thick bodies of "earlier" dolomite may conceivably be a function of increasing conditions of aridity in the source area. Tectonism, however, has been shown to be a dominant factor in determining the depositional characters of many sediments (Krynine, 1942, 1943, 1948; and others). That important tectonic movements have occurred in the basin of deposition during Lower and Middle Ordovician time in southeastern Pennsylvania is demonstrated by angular unconformities, erosional conglomerates, and missing strata. In view of this, it is plausible that the facies shifts during Beekmantown time were controlled primarily by movements of the basin floor which, as will be hypothesized for the sediments studied in the present investigation, increased in intensity with time, culminating in local upwarping of the floor in Middle Ordovician time.

According to the scheme of disatrophism proposed by Krynine in 1942, the Beekmantown-Lower Trenton sediments in the Great Valley of Pennsylvania formed in the early geosynclinal stage which was characterized by non-uniformity in rate of subsidence. Local upwarping exposed areas of these sediments to erosion. Cyclic deposits are characteristic of this stage as well as of the foregoing peneplanation stage.

Of particular importance in understanding the role of basin tectonics in Beekmantown time is correct interpretation of the small-scale limestone-dolomite cycles that characterize the Beekmantown in Berks and Lebanon Counties (Fig. 12). As studied in Berks County, the upright asymmetrical cycle (Fig. 13) is of particular volumetric importance. The characteristics of these cycles, presented in greater detail in the sections on petrology, are summarized as follows: (1) Within each cycle there is an apparent inverse relation between the amount of dolomite and both the degree of clasticity and proportion of bioclastics in the calcite fractions; the percentage of dolomite increases from the base of each cycle upward to the base of the succeeding cycle; (2) Within the mottled zones of each cycle there is an apparent direct relation between the percentage of dolomite and the proportion of lime mud in the calcite fraction; (3) The tubular and cylinder morphology of the dolomite mottles indicates

the work of organisms; (4) The apparent lateral persistence, regularity in thickness, microstratification, and barrenness of the dolomite beds at the top of each cycle suggest that they are the product of dolomite-producing depositional loci; they are classed as examples of "earlier" dolomite discussed in the foregoing section. Mudcracks in association, in at least two instances, with the dolomite indicate intermittent exposure; (5) The relatively high pyrite and limonite content of the dolomites and the small but characteristic pyrite content of the lime mud associated with the dolomitic-mottled and calcitic-mottled rock suggest reducing conditions in the bottom sediments; (6) The vertical relations of rock types in the cycles reflect orderly repetitions of rock-producing loci; (7) The fact that the total thickness of the recognized upright asymmetrical cycles makes up about one-third of the exposures of the lower member in the type section of the Epler indicates the importance of the cycles volumetrically; (8) The fact that 14 of the 16 upright asymmetrical cycles that have been recognized occur in the transgressive phase indicates that the cycle-producing phenomema were connected with transgression of the sea; (9) The abundance of these cycles in central Berks County which, as will be shown in a following section, was an area of profound post-Ontelaunee uplift and erosion suggests that basin tectonics may have played a role in their production.

Figure 24 summarizes a plausible sequence of events that may have resulted in the development of a typical upright cycle. The typical sequence is composed of three phases or stages. Stage 1, beginning the cycle, was characterized by normal marine circulation accompanied by wave and current action. Marine life was abundant. Stage 2, was a semi-restricted phase characterized by somewhat higher salinities and temperatures accompanied perhaps by shallowing water and was characterized by organic activity, perhaps in the form of algae or worms. Stage 3, the restricted stage, was one of supersaturated, relatively warm, quiet and possibly shallower waters with occasional mud flat conditions. There is no trace of former life in the rocks produced in this stage. Stages 2 and 3 were characterized, perhaps, by reducing conditions in the bottom sediments.

The restricted, supersaturated conditions giving rise to the dolomite beds terminated abruptly with the renewed deposition of limestone, inaugurating a new cycle. Apparently little or no scour of the dolomites resulted, as might be expected from wave action or strong current activity near the strand line, and it is concluded that the change from dolomite to limestone formation was accompanied by deepening waters in which mild water movements broke up and abraded the sediment in some place whereas at other places and times there were no visible clastic textures produced.

It is logical to seek an explanation for the series of cycles in the interplay of sedimentation rate, tectonic movements, and climate changes. Whereas the possi-

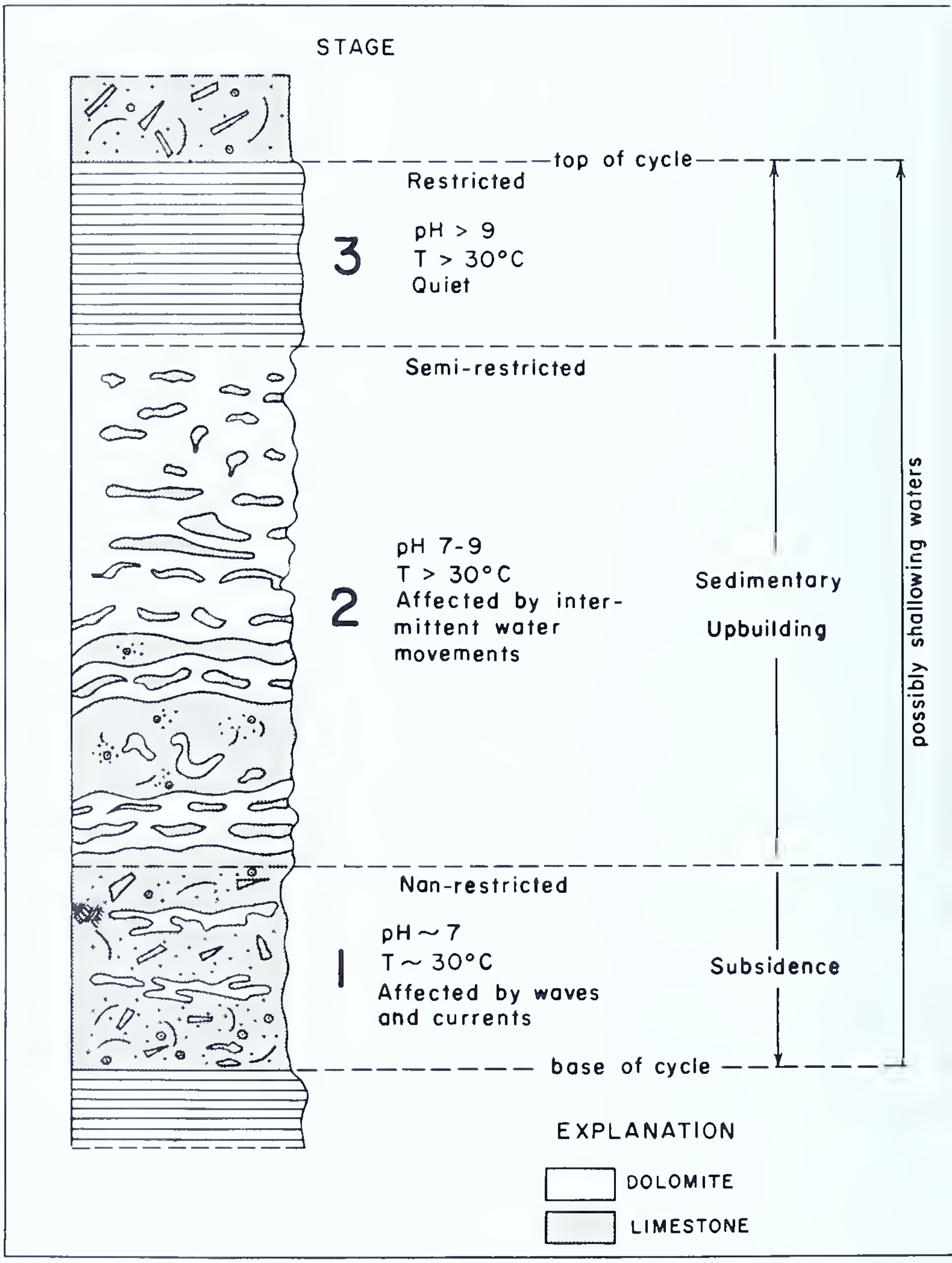

Figure 24. Paleogeographic interpretation of the upright asymmetrical cycle in the lower member of the Epler Formation, central Berks County

ble role of climate is unknown, there appears to be indication that the cycles occur in an area that underwent rapid shifts in facies and, as shown in a following section, experienced active tectonism in Ontelaunee-Jacksonburg time. The lower part of the Epler was exposed at section No. 14 in eastern Lebanon County does not show appreciable development of the upright cycles although dolomite-calcite mottling and dolomite interbeds are very common. Also, as has been discussed previously, the cycles apparently are confined for the most part to a transgressive phase through which normal marine limestones of the southwestern areas moved over the dolomites in central Berks County.

It is difficult to evaluate the relative importance of sedimentary upbuilding versus rate of subsidence during general down-drop of the basin floor. It might be expected from the fact that intermittent movements upward occurred in this area at a later time, that the basin may have subsided less rapidly at times allowing the upbuilding of sediment in relation to sea level and, thus, gradually attaining the restricted conditions favoring dolomite formation on the sea floor. With a relatively rapid down-drop in relation to the rate of sedimentation the unrestricted phase was entered quite rapidly.

Information is generally lacking on the relative rates of deposition for the petrological types of carbonate. In view of the thicker limestone sequence in southern Pennsylvania as compared to the predominantly dolomite sequence in Berks County below the upper cherty zone (3100 feet vs. 1800 feet), it seems reasonable to conclude that the rate of formation of the limestones was greater than that for the so-called "earlier" dolomites. It would also seem that the accumulation of bioclastic material, calcite sand and fragments, and clay in the lower part of many cycles results in a faster rate of deposition than does the slow precipitation of lime mud. If Stages 2 and 3 represent a decreasing rate of deposition, in relation to Stage 1, it becomes apparent that subsidence must have had a greater rate of decrease than sedimentation in order that the sediments be at or near sea level during the dolomite phase. The increasing effect of climatic factors promoting conditions of aridity would aid the shallowing of water in the "pans" and the formation of dolomite.

In summary it is suggested that a series of cycles may be caused by sedimentary upbuilding (restriction) and subsidence (renewed circulation) modified by climatic controls. Sedimentary upbuilding and restricted conditions occurred at times when subsidence of the sea bottom was relatively less than the rate of sedimentation and the stage of deepening, characterized by less restricted waters was caused by renewed and relatively rapid subsidence in an area where tectonic control of the basin was the dominant factor influencing sedimentation.

From consideration of the genesis of the limestone-dolomite cycles it is possible that the larger-scale changes in lithofacies subtypes in the area east

of the Susquehanna River may have occurred in a similar manner. If this is true, the development and lateral extension of the bodies of "earlier" dolomite were due to slowing rates of subsidence of the basin floor allowing widespread upbuilding and restriction.

During the same period of time, the Chambersburg area was undergoing a relatively uniform rate of subsidence keeping pace with sedimentation and resulting in a thicker sequence containing fewer lithofacies types.

As will be discussed in the following section, this condition of halting subsidence of the basin floor apparently gave way in early Middle Ordovician time to positive movements, resulting in restriction of sediments and unconformity.

Origin and Development of Post-Ontelaunee Unconformity

A number of somewhat different theories have been presented to explain the patchy outcrop distribution of the Jacksonburg Limestone (Stose, and Jonas, 1927; R. L. Miller, 1937; R. L. Miller *in* B. L. Miller, 1939, 1941; Gray, 1952b). Stose and Jonas (1927) believed that the patches of "Leesport" (Jacksonburg) Limestone southwest of the Lehigh River represent locally restricted deposits contemporaneous with the lower Martinsburg Shale and that the unconformity separating both the "Leesport" Limestone and the Martinsburg Shale from the Beekmantown dolomites in different places records post-Chazy, pre-Lower Trenton uplift and erosion, removing the Chazy-Black River sediments that were equivalent to those in the area southwest of the Susquehanna River. R. L. Miller (1937; *in* B. L. Miller, 1939, 1941) presented somewhat different views for the area east of the Schuylkill River although he accepted the conclusion of Stose and Jonas (1927, p. 510) that the "Leesport Limestone and Stones River Limestone (Annville of today) underlie the shale in perfect conformity" between Lebanon, central Lebanon County and Womelsdorf, western Berks County. Miller believed that east of the Schuylkill River significant erosion occurred in both pre-Jacksonburg time and in post-Jacksonburg time and that the Martinsburg Shale was deposited on beveled folds. In his 1937 publication Miller believed that the Jacksonburg was missing in the Limeport area in Lehigh County by nondeposition (p. 1709). In 1941 (p. 211), he suggested that the Jacksonburg sediments had mantled even the Limeport area and were removed by later upwarping and erosion in that area.

Gray (1952b) presented a somewhat different explanation of the nature of the base of the Martinsburg in Berks County. Gray agreed with Stose and Jonas and R. L. Miller that the Jacksonburg-Martinsburg relations are transitional in Berks County but he also observed that where the limestone sequence is incomplete there are no limey beds in the Martinsburg near the lower contact. Gray also noted that where the most abrupt "pinch outs" of Jackson-

burg occur, sandstone and quartz-pebble conglomerates, which he thought resembled channel deposits, occur in the Martinsburg, and that in places, as at Womelsdorf, western Berks County and near Stoudt's Bridge, central Berks County, the "pinch out" of Jacksonburg is quite abrupt, even when allowance is made for tectonic shortening of the distance between the locus of Jacksonburg deposition and that where shale was deposited directly on the dolomite. Gray concluded from these observations that erosion had occurred in early Martinsburg time by deep channeling on a broadly arching terrain which resulted in removal of the transitional beds and, in places, the entire Jacksonburg.

In the writer's opinion, the facts set forth for the area between the Susquehanna and Schuylkill Rivers by Stose and Jonas (1927), Gray (1952b), Prouty (in Gray, 1952a; 1959), and the present writer may be given a somewhat different interpretation. Of particular importance in evaluating the nature of the unconformity and the mode of deposition of the Late Beekmantown and Middle Ordovician sediments is the position of the sediments in the stratigraphic framework (Fig. 21), especially the disposition of the Hershey conglomerate of central Dauphin County and western Berks County. As shown in the discussion of the stratigraphy of the Ontlaunee Formation the conglomerate in the basal Hershey of western Berks County is an allochthonous conglomerate composed of fragments of dolomite. The angularity and poor size- and shape-sorting of the fragments suggest short transport and rapid burial. As shown in the discussion of the regional stratigraphy of the Ontelaunee Formation, the proximity of Martinsburg-Ontelaunee (and in places, Epler) contacts to the conglomerate occurrences, as well as the lithology of the fragments, indicates that the conglomerate was derived in large part by erosion of Ontelaunee dolomite in western and central Berks County. A similiar relation may exist, much more locally, southwest of Berks County in central and western Dauphin County, although in this place the conglomerate is not so well developed. In both areas, the conglomerate extends to the base of the Hershey, implying the existence of nearby eroding high simultaneous with the onset of deposition of the argillaceous limestone in Hershey time and following deposition of the Annville and Myerstown Limestones. Prouty (1959) has recently emphasized this fact.

The upper, dark dolomites of the Ontelaunee, the Annville Limestone, and the Jacksonburg limestones are missing in parts of central Berks County. It seems possible that a somewhat similar relation occurs in central Dauphin County. Martinsburg-Beekmantown contacts have been observed in both places although those in Dauphin County may conceivably be fault contacts. Disappearance of the upper Ontelaunee-Hershey beds may indicate, (1) termination of sediments against the flanks of topographic highs such as must have been the source for the Hershey conglomerate, or (2) overall deposition followed by local erosion. The following observations lead the writer to tentatively propose the first alter-

native as the more accurate interpretation, at least in the case of the Reading area: (1) The dark, lithological character of the uppermost Ontelaunee and interbedded thin layers of carbonaceous material in Lebanon County imply poor circulation of waters during deposition of these beds; formation of these dark dolomites would require at least partial restriction; (2) there is no evidence known to the writer of limestone fragments of Annville or Myerstown in the Hershey conglomerate suggesting that they were not involved in the strongly physical erosion; (3) The Annville thins both east and west from central Lebanon County beneath the Myerstown Limestone; (4) The Annville is pure and free from detritals; (5) With the exception of a single questionable identification in the Easton quadrangle (Prouty, 1959, p. 11) the Annville is not present in the sequence from the Reading area northeastward; and (6) A structural and facies barrier has been known to exist in the Harrisburg area during Middle Ordovician time (see Prouty, 1959, p. 31). Myerstown limestones are present in the southern limb of the Steelton syncline of central Dauphin County but exposures have not been observed in the Harrisburg belt (Prouty, 1959, p. 15). Prouty ascribes the absence of Myerstown in the Harrisburg belt to faulting. However, the writer believes that the Myerstown may be gone by unconformity in section No. 24, as previously discussed. Prouty has measured the Myerstown as 56 feet thick in the extensively faulted type section of the Myerstown and Hershey southwest of Hummelstown, considerably thinner than the 150 feet or so at Stouchsburg to the east and the 270 feet in south Steelton. Prouty's Hummelstown section is only a few miles southeast of section No. 24 where Martinsburg-Ontelaunee and Hershey (?) -Ontelaunee contacts have been interpreted as unconformities in the present study.

Partial restriction through uppermost Ontelaunee, Annville, and Myerstown times in Lebanon County may have been due to actual positive movements of adjacent parts of the basin floor or to locally slower rates of subsidence. This condition gave way to marked uplift of the "positive" areas contemporaneous with the first influx of Hershey clays and depositions of the Hershey conglomerates. It seems reasonable that these movements in the basin paralleled a condition of increased uplift in the source area which resulted in the influx of clays. After deposition of the conglomerate, a general condition of overall subsidence allowed sedimentation to continue in the downwarped areas and many places where the Annville and Myerstown limestones were not deposited in central Berks County received later Hershey sediments. Eventually, deposition of argillaceous limestones gave way to deposition of Martinsburg shale which completely covered the preexisting highs. If valleys or channels existed on the flanks of the highs, those would be filled with Hershey sediments and the interfluves subsequently covered by Martinsburg clays. Such a condition would give rise to abrupt "pinch outs" of the Jacksonburg similar to those described by Gray (1952b). The quartz-

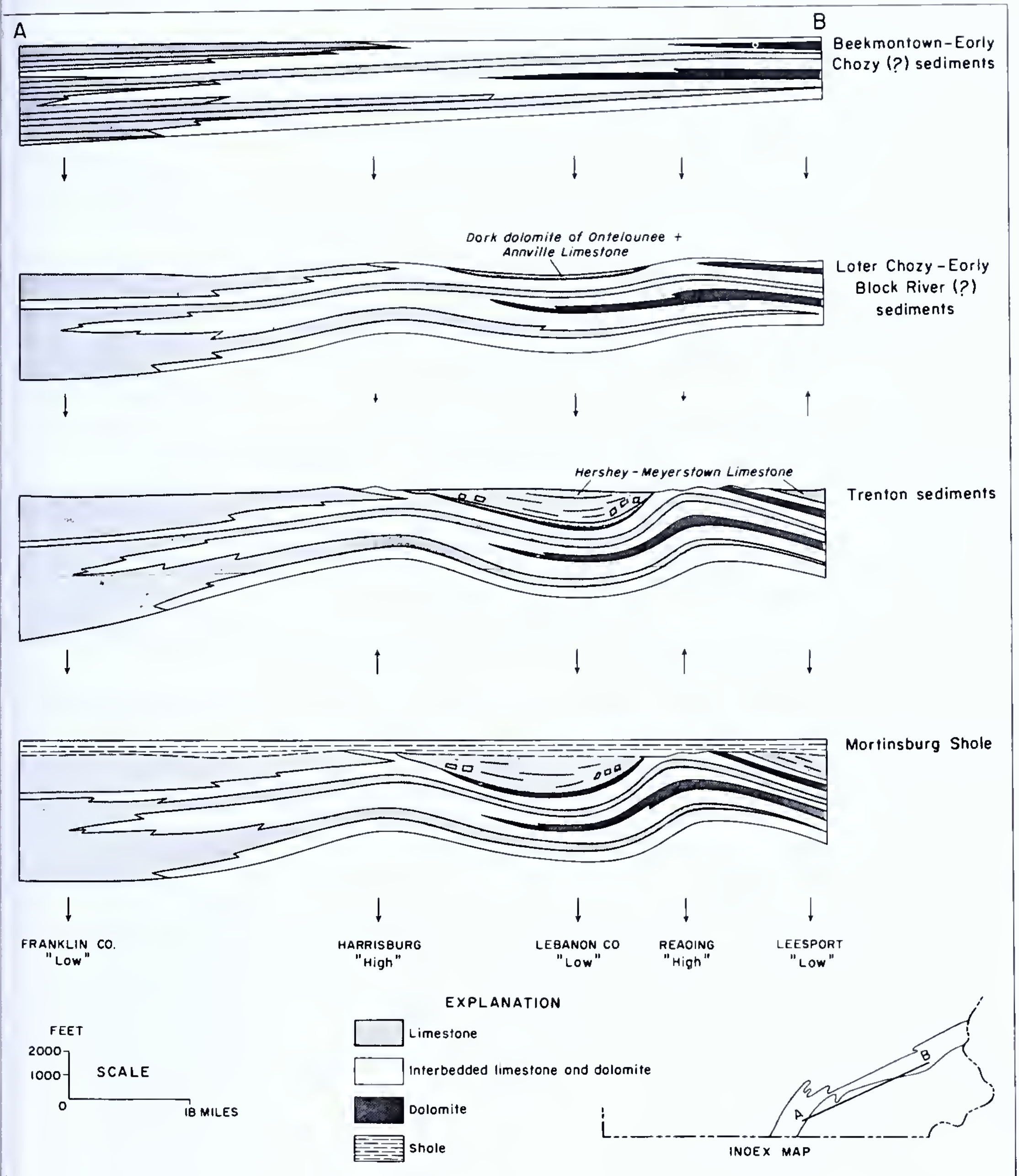

Figure 25.

Possible development of Beekmantown and Middle ordovician sediments from eastern Franklin County to Schuylkill River.

Table 7. *Tectonic elements and possible history of sedimentation of Beekmantown and Middle Ordovician rocks from eastern Franklin County to Schuylkill River.*

	Franklin Co. low	Harrisburg high	Lebanon Co. low	Reading high	Leesport low
Trenton	Deposition	Local erosion in early Trenton followed by period of nondeposition; deposition of Hershey-Myerstown limestones in places; deposition of Martinsburg shale.	Deposition of the Myerstown limestone; deposition of Hershey conglomerate in eastern and western parts followed by deposition of the Hershey limestone and Martinsburg shale.	Erosion in early Trenton, followed by period of nondeposition; deposition of Martinsburg shale.	Deposition of Jacksonburg limestone, followed by deposition of Martinsburg shale. Possible volcanic deposits in lower Jacksonburg sediments.
Black River	Deposition	Nondeposition (?)	Nondeposition (?)	Nondeposition (?)	Nondeposition (?)
Chazy	Deposition	Deposition of the upper part of the Ontelaunee (?)	Deposition of upper Ontelaunee (?) including the uppermost dark dolomites and deposition of Annville limestone.	Deposition of the upper part of the Ontelaunee. (?)	Deposition of the upper part of the Ontelaunee. (?)
Beekmantown	Deposition of Stonehenge and Rockdale Run Formations, including dolomites and chert at the top.	Deposition of Stonehenge limestone, Epler (or Rockdale Run) sediments, and lower part of the Ontelaunee including chert.	Deposition of Stonehenge limestone, Rickenbach dolomite, Epler Formation, and the lower part of the Ontelaunee Formation, including chert.		

pebble conglomerates in the base of the Martinsburg give no known indication, in the form of limestone or dolomite fragments, of having been derived by channeling of carbonates as suggested by Gray. Sandstones are reportedly common in at least the lower 690 feet or so of the Martinsburg (Stose and Jonas, 1927, p. 256). In the writer's opinion, these conglomerates and sandstones likely were derived from nearby igneous or metamorphic crystallines or quartz-bearing sediments and represent deposits swept into the basin with the clays.

It is the suggestion of the writer, therefore, that the uppermost Ontelaunee dolomite of Lebanon County, the Annville limestone, and possibly the Myerstown and Hershey limestones may have been deposited between (and around ?) tectonic and physiographic highs which were located in the central Dauphin County area to the southwest and in the central Berks County area to the northeast. In the Dauphin County area the barrier was less complete, perhaps consisting of low islands. Figure 25 and Table 7 summarize the steps by which the writer believes the rock succession may have accumulated in these areas. In order to differentiate the various tectonic elements in the study area the following names are applied from southwest to northeast in Figure 25 and Table 7: (1) Franklin County low, (2) Harrisburg high (part of "Harrisburg axis" of Ulrich, 1911), (3) Lebanon County low, (4) Reading high (part of "Reading arch" of Prouty, 1959) and (5) Leesport low. Designated in this fashion there is no implication as to a particular physiographic or structural form. Ulrich (1911) postulated a northwest trend for the "Harrisburg axis", and Prouty (1959) envisages a low, broad structure trending north-northeast. Prouty (1959) also mentions a "Reading Arch" line from New Jersey to southeast Pennsylvania. The distribution of Martinsburg-Beekmantown contacts from Oley Valley through the Wyomissing (Reading) area to Host in western Berks County suggests that the positive area may have had a considerable extension to the northwest of the Reading Prong area. Indeed, a northwest-trending structure in the immediate area is suggested. In parts of this area the Martinsburg Shale rests on Conococheague and older beds (Gray and others, 1960).

The arrows in Figure 25 indicate, in general fashion, the *relative* direction of movement of the basin floor in the respective areas during the various time periods. If the picture presented here for the Susquehanna River-Schuylkill River is correct, it may be that much of the patchiness of Hershey-Myerstown outcrop to the northeast is the result of similar conditions of deposition. Recently, however, Ray and Gault (1961) have presented mineralogic evidence supporting R. L. Miller's (*in* B. L. Miller, 1941, p. 211) earlier view that the Jacksonburg rocks were deposited essentially over the entire area and were later stripped away by erosion in places.

SOME FOSSILS OF THE BEEKMANTOWN GROUP IN SOUTHEASTERN PENNSYLVANIA

Fossils have been reported or described from rocks now included in the Beekmantown Group of southeastern Pennsylvania by Prime (1883), Lesley (1889), Ulrich (1911), Miller (1911, 1939, 1941), and Willard (1958, p. 177).

During description of the exposures in this study, fossiliferous strata have been noted and some attempt made to collect specimens that would afford identifications. Most of the specimens have been uncovered in Berks County; however, fossils are also common in some exposures in Lebanon County.

The faunal content of the various formations has been discussed in the sections dealing with the stratigraphy of the units. More detailed descriptions of the specimens found in the study may be referred to in Hobson (1958a). Some of the better specimens are pictured in Plate 22.

The following is a list of fossils found in the study and the formations in which they were found.

Beekmantown Faunal List
(See Plate 22)

BRACHIOPODS	Occurrence
Nanorthis sp.	Stonehenge Formation, Berks County
Finkelnburgia sp.	Stonehenge and Epler Formations, Berks County
? diparelasmid brachiopods	Epler Formation, Berks County

PLATE 22

Figure 1—*Nanorthis*? sp. Dorsal view?, X4. From the Stonehenge Formation, Section 11.

2, 3—*Finkelburgia* sp. 2, X3; 3, internal mold of ? ventral valve, X3.5. 2, from the Stonehenge Formation, Section 11. 3, from the Epler Formation, Section 11.

4—diparelasmid? brachiopod. Internal mold with silicified shell remnant, X3. From the Epler Formation, Section 4.

5, 6—*Hormotoma*? sp. Cross sections of internal molds and shells; 5, X3; 6, X1. From the Epler Formation, Sections 4 and 15 respectively.

7, 8—*Raphistoma?* sp. 7, apical view, X3.5; 2, side view, X2. From the Epler Formation, Section 4.

9, 10—*Ophileta* sp. 10, oblique apical view, X1.5; 9, side view, X1.5. From the Epler Formation, Section 4.

11—*Maclurites* sp. Ventral view of mold. From float of Epler Formation lithology, near contact of Beekmantown and Martinsburg Formations, Reading quadrangle.

12—bathyurid trilobite. Cephalon, X3.5. From the Epler Formation, Section 4.

13, 14—hystricurid trilobite. 13, portions of cephalon, X4; 14, pygidium, X4. From the Stonehenge Formation, Section 11.

15—orthoceroid cephalopod. X3. From the Rickenbach Formation, Section 11.

PLATE 22

GASTROPODS

Hormotoma ? sp.	Ontelaunee and Epler Formations, Berks County, Epler Formation, Lebanon County
Raphistoma ? sp.	Epler Formation, Berks County
Ophileta sp.	Epler and Stonehenge Formations, Berks County, Epler Formation, Lebanon County
Maclurites sp.	Epler Formation, Berks County; Float of Epler (?) lithology, Berks County

CEPHALOPODS

orthoceroid cephalopods	Rickenbach and Ontelaunee Formations, Berks County

ARTHROPODS

bathyurid trilobites	Epler Formation, Berks County
hystricurid trilobites	Stonehenge Formation, Berks County
ostracodes	Epler Formation, Berks and Lebanon Counties; Ontelaunee Formation, Lebanon and Dauphin Counties

ALGAE

stromatolites	Epler and Stonehenge Formations, Berks County,
cryptozoon type	Epler Formation, Berks County
gymnosolen type	Stonehenge Formation, Berks County

UNASSIGNED

fucoids	Ontelaunee, Epler and Stonehenge Formations, throughout area of study.

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APPENDIX I

DETAILED PETROGRAPHY OF ROCK TYPES

Introduction and Procedures

Grouping of rock types and rock subtypes

An effort has been made to obtain a sample from every rock type and every megacopically-visible variation within a rock type. To this degree, the number of samples is in proportion to variability in observed compositional, textural, and structural characters. More than 400 samples from key sections in Lebanon and Berks Counties have been collected. The upper bedding surface has been indicated on each sample.

In the laboratory the samples have been taken from their stratigraphic order and combined into rock type groups according to gross composition and texture. Subgroups (subtypes) are based in most cases on the kinds of sedimentary structures or the apparent absence of such structures. Grouping of rock types and subtypes is helpful in the study of lithologies and stratigraphy in the following respects: experience gained from detecting differences and similarities in rocks being studied is valuable to the investigator; grouping the samples according to lithologies allows the worker to estimate variability of rock characters between and within the types by visual comparison of samples; selection of samples for further analysis is facilitated; and undue emphasis of unusual or "interesting" lithological characters is avoided.

Preparation of etched sections

Samples for acid etching were selected from each subtype. Petrographic slides (thin sections) were largely chosen after preliminary examination of etched sections. Etched sections were prepared from rock slabs one-fourth inch or so thick, cut perpendicular to bedding. A small slot was cut in the upper edge of each slab. Saw marks were then removed with coarse abrasive powder and a rough polish obtained with finer abrasive. The slabs were placed with the polished surface upward in a dish of 10 percent hydrochloric acid for one or two minutes, carefully washed, dried, and mounted on stiff, black cards. More than 250 etched sections were examined during the study.

In special cases rock components were identified with the aid of X-ray spectrometer and of immersion oils.

Procedure for thin and etched section study

The petrologic study of each subtype was divided into a preliminar description-classification stage, a detailed description stage, and a stage concerned with synthesis into genetic classes based on descriptive data. The following procedure is essentially that taught by Dr. P. D. Krynine at The Pennsylvania State University.

I Preliminary description, listing the mineralogical constituent and classes of textural-morphological components.

II Description of each class of textural-morphological componer including the following observations:
- A. Identification of component
- B. External morphology of component
  - 1. Unit properties
    - a. size
    - b. habit
    - c. sphericity
    - d. roundness
    - e. modification of original shape
  - 2. Surface properties
    - a. surface texture
    - b. color
    - c. relief
- C Internal morphology of component
  - 1. Optical
  - 2. Physical
    - a. inclusions
    - b. overgrowths
    - c. zoning
- D. Fabric relations of component
  - 1. Orientation and alignment
  - 2. Packing
- E. Structural occurrence of component

III Genesis of each component (clastic vs. nonclastic, authigenic etc.)

IV Genesis of rock type

Presentation of data

The seven rock types (B-1 through B-7) and the 28 subtypes (B-1a, B-3b, etc.) have been given numbers based on the Beekmantown as a

whole rather than on the individual formations. Foregoing sections of the paper deal with the megascopic characteristics of rocks in the various classes and their distribution in the formation in central Berks County. Following are descriptions of each rock type, principally as studied in microscopic fashion.

Dolomite Rock Types

Introduction

Two major dolomite rock types, B-1 and B-2, have been recognized in the study. The dolomite types and subtypes are listed below.

Dolomite (B-1), microcrystalline to finely megacrystalline:
(B-1a), apparently structureless
(B-1b), light- and dark-laminated
(B-1c), calcitic-laminated
(B-1d), calcitic-mottled
(B-1e), light- and dark-mottled
(B-1f), siliceous-laminated or -mottled (some cherty types)
(B-1g), arenaceous (quartz sand)
(B-1h), calcarenitic (calcite sand)
(B-1i), brecciated
(B-1j), cherty

Dolomite (B-2), medium to coarsely megacrystalline:
(B-2a), apparently structureless
(B-2b), light- and dark-laminated
(B-2c), siliceous-mottled and -streaked (some cherty types)
(B-2d), "paradoloarenitic" and "paradoloruditic"
(B-2e), "microfractured"
(B-2f), brecciated

Rock type B-1

Composition - X-ray analyses and acid etching of rock type B-1 indicate a strong predominance of dolomite mineral except in subtypes B-1c, B-1d, B-1e, and B-1h. Calcite where present in subtypes B-1a and B-1b occurs in finely disseminated fashion. Both dolomite and calcite peaks occur at their normal positions in the X-ray diffraction patterns. The position of the dolomite peak is the same for all samples analyzed, indicating little variation in dolomite lattice spacing in the rock type.

Texture - Textural elements in rock type B-1 are as follows, in order

of decreasing volumetric importance of the main elements.

Grains: dolomite, quartz, feldspar, pyrite
Matrix: limonitic-stained matter, microcrystalline dolomite and calcite
Cement: limonite, chert

Although dolomite of type B-1 is generally composed of crystals smaller than 1/8 mm., crystals ranging up to 1/4 mm. are common. The smaller crystals are anhedral to subhedral, the crystal form being less well developed as the grain size decreases (Plate 13, Figs. 1, 2). Straight to concavo-convex crystal contacts are the rule. Within a sedimentary structure a single class on the Wentworth scale may contain three-fourths of the crystal grains within the area covered by a thin section. Microcrystalline and submicrocrystalline dolomite, whereas common, does not appear to be the predominant texture in type B-1. Very-finely-megacrystalline dolomite (1/8-1/16 mm.) appears to be the most common textural class.

Structure - Acid etching of rock type B-1 reveals a wealth and diversity of sedimentary structures that are unsuspected from observation of fresh surfaces. The observed structures are broadly classed as follows

A. Laminae and bands
   1. regular, parallel laminae and bands
   2. irregular and discontinuous, subparallel laminae and bands
   3. small-scale folds

B. Mottling
   1. color mottling
   2. cherty mottling

C. "arborescent" structures (Pl. 13, Figs. 3-5)

D. chert nodules, sub-nodules and stringers

E. mudcracks

F. small-scale scour surfaces

G. small-scale cross bedding

Laminae in most cases are caused by variations in limonitic-stained matrix, concentrations of quartz and feldspar silt (Pl. 14, Figs. 1, 2), variation in crystal size of the dolomite grains (Pl. 13, Fig. 1),

Table 8

Petrographic rock characteristics of subtype B-3c

Stonehenge limestone, Section No. 1
Petrographic class: Bioclastic calcilutite
Genesis: Modified nonclastic
Illustrated in Plate 17

Textural-Morphological Components	Sand and fragments (Grains)	Bioclastics (Grains)	Submicrocrystalline and microcrystalline aggregate (Matrix)	Megacrystalline aggregate (Cement)	Unit crystalline (Grains)	Noncarbonate (Grains and Matrix)	Unit crystalline and megacrystalline aggregate (Grains)
Composition	Calcite	Calcite	Calcite	Calcite	Calcite	Quartz and feldspar, pyrite, clayey matrial	Dolomite
Percent Slide no. 1122	67 (Majority sand)	8 0	78.3	4.0	0 6	0 4	2.0 (low for rock type in general)
Size and Shape; Internal organization	Long dimensions about 1/16 to 3 mm., average about 1/2 mm.; subangular to rounded, equant to platy; surface texture smooth but characteristically rough with pits and dents, particles composed of interlocking submicrocrystalline and microcrystalline calcite (less than 1/32 mm.); several fragments with limonitic stained central parts which have a configuration paralleling that of the enclosing fragments.	Fibrous, bent and crushed but generally unbroken, brachiopod valves up to 10 mm. in length; pelmatozoan fragments, dusty-gray crystals and columnal-shaped crystals with sparry, optically continuous overgrowths; trilobite fragments composed of microcrystalline calcite and with characteristic extinction waves, commonly with rounded ends, several yoke-shaped fragments.	Crystals smaller than 1/32 mm., anhedral, scattered patches of larger crystals. Majority texturally similar to that making up fragments and sand. Distorted stromatolites, microfolded laminae and elongated, aligned calcite crystals are commonly associated with coarser matrix.	Crystal size range about 1/4 to 1-1/2 mm.; anhedral; clear; with cleavage and twins.	Small anhedral, angular, sparry crystals; clear and commonly twinned; contrast with dusty, rounded pelmatozoan crystals.	Quartz-feldspar grains are about 1/32-1/10 mm. in size; undulose to straight extinction; few bubble-like inclusions; rough, pitted surface texture, several polysynthetic twins. Crystals are commonly intergrown with matrix calcite where they are distinguishable with difficulty at low magnifications. Pyrite as idiomorphic brass-yellow cubes in reflected light, somewhat altered to limonite in places. Clayey matter is dark brownish.	Crystal size range about 1/32-1/2 mm., euhedral to anhedral; several crystals have an apparent subrounded aspect; clear to dusty interiors.
Interrelations	Loosely packed, fragment-to-fragment contacts uncommon, surrounded by somewhat coarser-grained calcite; fragments in "jumbled" arrangement, rarely the apparent axes subparallel bedding	Loosely packed in matrix calcite; more closely packed in the clastic patches. Apparently no orientation of shells with respect to bedding (in contrast to some samples of type B-5, in the Stonehenge which show a pronounced orientation of the shells parallel to bedding)	Interlocking crystalline; enclosing bioclastics, indistinct fragments, pyrite, unit-crystalline calcite, and quartz-feldspar grains. Intermixed with grains in clastic lenses resulting in a poorly sorted appearance.	Interlocking crystalline; separated by sharp irregular boundary from surrounding rock.	Enclosed in matrix calcite.	Quartz-feldspar and pyrite enclosed in matrix calcite and concentrated in silty-argillaceous laminae where intermixed with darker, limonitic-stained argillaceous material. Pyrite in clusters. Quartz-feldspar loosely packed in matrix and tightly packed in laminae with clayey matter.	Anhedral grains are tightly packed (interlocking crystalline) with concavo-convex and straight contacts and found in lenses and patches commonly in association with organic structures ("borings", small reef-like structures). Euhedral grains are loosely packed in lenses and silty-argillaceous laminae; a number of crystals possess overgrowths and iron-stained borders.
Structural disposition	Scatterrd irregular patches and pockets.	Scattered throughout rock, somewhat concentrated in clastic patches.	Makes up bulk of rock.	Irregular, tapering vein-filled fractures.	Scattered throughout matrix.	Scattered throughout matrix and concentrated in irregular laminae and streaks.	In patches, lenses, cylinders, and irregular silty-argillaceous laminae.
Genesis	Clastic, breakup of lime matrix, possible slumping.	Clastic; dissociation and probable mild movements, brachiopod shells affected by crushing action.	Probably nonclastic; possibly biochemical in part; affected in part by recrystallization and rock flowage; matrix may be clastic in patches where intermixed with bioclastics and fragments.	Probably authigenic cavity filling.	Authigenic? Recrystallization of matrix?	Quartz, feldspar and clays probably detrital; pyrite authigenic.	Probably originated by replacement of Mg-enriched matrix calcite.

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Table 9

Petrographic rock characteristics of subtype II-3a in sample 1697

Epler limestone, Section No. 4
Petrographic class: Sandy calcilutite
Genesis: Modified nonclastic

Not illustrated

Textural-Morphological Components	Sand (Grains)	Bioclastics (Grains)	Submicrocrystalline aggregate (Matrix)	Megacrystalline aggregate (Cement)	Megacrystalline aggregate (Grains and cement)	Noncarbonate (Grains and matrix)
Composition	Calcite	Calcite	Calcite	Calcite	Dolomite	Argillaceous material, pyrite and alteration products
Percent	21.0	trace	51.3	12.7	6.3	4.4 (opaque matter only)
Size and shape; internal organization	Size range about 1/16-1 mm, average about 1/10 mm; rounded; equant; smooth to "fuzzy" surface texture; composed of finely micro-crystalline to submicrocrystalline calcite; count does not include some closely packed sand grains of calcite.	Two broken microcrystalline trilobite fragments and several dusty-gray, rounded pelmatozoan fragments with sparry calcite overgrowths.	Finely microcrystalline to submicrocrystalline; anhedral. Count includes some coarser material as well as areas of closely packed calcite sand grains	Coarsely microcrystalline to finely megacrystalline; anhedral; count includes some finely microcrystalline matrix calcite	Average size about 1/16 mm; varies from anhedral to euhedral but largely subhedral; well-formed crystals outside of clusters. Iron-stained borders common	Small 1/8-1/4 mm patches of a blood-red, opaque mineral resembling hematite with yellowish to brownish borders is common; brass-yellow pyrite occurs as scattered specks and as centers in several of the patches of reddish mineral; limonite as intercrystalline staining and opaque clusters.
Fabric relations	Moderately well packed; touching contacts common; cemented by sparry calcite cement; in some places tightly packed so that grains are distinguishable with difficulty from unfragmented matrix calcite.	Loosely packed; enclosed in calcite matrix, sand and sparry cement.	Interlocking crystalline; intermixed with sand, bioclastics and enclosing dolomite in places; gradational with cement	Interlocking crystalline; cementing calcite grains and matrix; some as vein filling; grades into matrix in some places	Interlocking crystalline anhedra and subhedra; floating euhedra in matrix of calcite or concentrated in argillaceous matter of stylolites; one well formed euhedra encloses part of vein calcite and matrix	Limonitic matter surrounds dolomite crystals and intermixed with calcite matrix; blood-red mineral and pyrite in clusters and scattered specks in lime mud and in stylolitic laminae
Structural deposition	In patches and disseminated through irregular laminae and bands.	Scattered throughout rock.	Makes up bulk of rock; disseminated in irregular patches through clastic lenses.	Disseminated through clastic lenses.	Irregular lenses and clusters and stylolitic laminae.	Largely concentrated in stylolitic laminae.
Genesis	Clastic, breakup of lime mud.	Clastic, dissociation and movement.	Clastic or nonclastic.	May be a chemical precipitate or a product of recrystallization.	Replacement	Argillaceous material probably detrital; pyrite authigenic.

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Table 10

Petrographic rock characteristics of subtype B-12

Stonehenge limestone
Petrographic class: Sandy calcilutite
Genesis: Modified nonclastic, in part
Illustrated in Plate 18, Figs. 1-3.

Textural-Morphological Components	Sand and fragments (Grains)	Bioclastics (Grains)	Microcrystalline aggregate (Matrix)	Megacrystalline aggregate (Cement)	Unit crystalline (Grains)	Microcrystalline complex of calcite, quartz and feldspar, chert, clay and micas, dolomite, pyrite and alteration products, organic matter. (Grains, matrix, and cement)
Composition	Calcite with enclosed quartz-feldspar	Calcite	Calcite (includes scattered quartz-feldspar)	Calcite	Dolomite	
Percent Slide no. 1113	4.4	5.4	70.0	12.2	0.1	7.9
Size and shape; internal organization	Size about 1/10 mm., equant to elongate; rounded to angular; smooth surface texture; composed of unlaminated submicrocrystalline calcite; scattered quartz and feldspar grains in fragments; some fragments colored pinkish.	Rounded grains of pelmatozoan stems; ranging in size from about 1/10 to 1/2 mm.; smooth boundaries separate dusty gray interiors and clear overgrowths in optical continuity with interior; rounded microcrystalline trilobite fragments with typical extinction "waves".	Finely microcrystalline (1/64-1/256 mm., average about 1/200 mm.); indistinct mosaic texture in places composed of anhedral crystals; grading into patches of submicrocrystalline calcite. Count may include some megacrystalline or coarsely microcrystalline calcite.	Crystal size range about 1/16 to 1 mm., anhedral; clear with cleavage and twins; as cement and overgrowths; about 1 percent of count is cavity and vein filling.	Size range about 1/16-1/3 mm.; euhedral to anhedral; dusty interiors and clear overgrowths in some well-formed crystals. Count does not include euhedra associated with microcrystalline complex.	Mixture of microcrystalline calcite, gray cloudy submicrocrystalline chert, platy minerals, scattered dolomite euhedra, pyrite, limonite and a blood-red mineral. Dark coloring matter may be organic in part.
Fabric relations	Loosely packed, floating to touching fragment-to-fragment contacts; fragments separated by microcrystalline calcite and pelmatozoan sand, all cemented by clear calcite (cement plus overgrowths).	Moderately well packed; intermixed with shells and fragments; cemented by sparry calcite.	Interlocking crystalline, enclosing scattered quartz-feldspar silt grains with pitted borders; intermixed with dark clayey material and microcrystalline silica in vicinity of siliceous laminae and mottles.	Interlocking crystalline cementing fragments, sand, and bioclastics; minor part as aggregates with sharp irregular contacts with calcite matrix.	Loosely packed, floating to touching contacts with several straight contacts; most commonly intermixed with dark clayey and siliceous iron-stained calcite that borders microcrystalline complex.	Interlocking complex with thin internal laminae caused by alternation of laminae of platy minerals, chert and calcite, and quartz-feldspar; gradational with adjacent calcite matrix with gradual decrease of noncalcite material outward from centers of laminae; in etched section borders of siliceous mottles show siliceous network.
Structural relations	Lenses and pockets.	Lenses and pockets.	Lenses and irregular, discontinuous bands.	Intergranular in lenses and pockets, other as vein filled fractures.	Scattered and in small clusters.	Irregular laminae and reticulate mottling.
Genesis	Clastic, breakup of matrix with addition and mixing of bioclastics.	Clastic, dissociation and movement.	Nonclastic (?) with detrital quartz-feldspar.	Authigenic vein filling; cement may be authigenic or product of recrystallization.	Dolomitization of Mg-enriched calcite matrix (addition or concentration of clay).	Genesis uncertain, structures may be due to activity of organisms (algae?) in building and binding sediment. Mineral components have variable genesis.

Table 11

Petrographic rock characteristics of subtype B-4a

Stonehenge limestone, Section No. 1
Petrographic class: Sandy calcilutite
Genesis: Clastic in part

Illustrated in Plate 18, Figs. 4-7

Textural Morphological Components	Sand and silt (Grains)	Bioclastics (Grains)	Megacrystalline aggregate (Grains)	Unit crystalline (Grains)	Megacrystalline aggregate (Grains and cement)	Noncarbonate (Grains)	Microcrystalline complex of calcite, quartz, and feldspar, chert, clay and micas, dolomite, pyrite and alternation products, organic matter. (Grains, matrix, and cement)
Composition	Calcite	Calcite	Calcite	Dolomite	Dolomite	Quartz-feldspar, micas	
Percent Slide No. 1114	31.0	Trace	55.0	3.0	Not present in slide	7.0	4.0
Size and shape; internal organization	Size range about 1/64-1/10 mm, average about 1/32 mm; equant, oval to sausage-shaped; rounded, contacts with cement are indistinct in places; mostly composed of microcrystalline calcite but pelmatozoan grains common; count includes line pelmatozoan grains; well-sorted according to size, little matrix material.	Dusty gray about 1/64-crystals about 1/25-1/12 mm in size; rounded, equant to slightly elongate; twinning and cleavage continuous with dusty interiors and sparry overgrowths; broken, fibrous brachiopod valves numerous in some samples along with microcrystalline trilobite fragments.	Crystal size range about 1/10-1 mm, cementing material about 1/12 mm; anhedral; clear crystals with cleavage and twinning.	Crystal size range about 1/40-1/5 mm; euhedral to anhedral; dusty, commonly with clear overgrowths.	Crystal size range about 1/16-1/5 mm; anhedral to subhedral; commonly dusty.	Quartz-feldspar size range about 1/40-1/5 mm; equant to elongate; many doubly terminated idiomorphic crystals; twins rare; pitted surface texture; bubble-like inclusions. Micas usually less than 1/4 mm in length; highly birefringent; parallel, crinkly extinction; wellformed platy crystals which reflect on broken surface.	Mixture of microcrystalline calcite, gray cloudy submicrocrystalline chert, platy minerals, scattered dolomite euhedra, pyrite, limonite, and a bloodred mineral. Dark coloring matter may be organic in part.
Fabric relations	Moderately packed, although touching contacts fairly uncommon, boundaries probably modified by recrystallization; cemented by sparry calcite cement and intermixed with larger bioclastics.	Smaller pelmatozoan grains moderately well packed and cemented by sparry calcite; larger bioclastics scattered, elongate fragments and shells commonly aligned subparallel to bedding.	Interlocking crystalline calcite cementing grains and bioclastics; commonly as overgrowth material on pelmatozoan fragments; less than 1 percent as aggregates in veins.	Loosely packed in dark, iron-stained clayey calcite matrix bordering microcrystalline complex and in circular clusters resembling cross-sections of organic borings.	Interlocking crystalline patchy aggregates cementing calcite grains, quartz-feldspar grains, and bioclastics; also as interlocking crystalline without enclosed material or with scattered quartz-feldspar. Rock subtype B-4c similar to subtype B-4a but with dolomite laminae and bands.	Quartz - feldspar scattered in calcite matrix to closely packed in laminae; intermixed in laminae with calcite sand and cemented by dolomite and sparry calcite. Micas scattered and parallel to bedding throughout.	Interlocking complex with thin internal laminae caused by alteration of layers of platy minerals, chert and calcite, and quartz-feldspar; gradational with adjacent calcite matrix with gradual decrease of non-calcite material outward from centers of laminae
Structural disposition	Disseminated through regular laminae and bands.	Scattered and clustered in clastic laminae and bands.	Disseminated through clastic parts of rock.	Scattered throughout dark laminae and in circular clusters.	Bands and thin, cross-bedded laminae.	Scattered and in thin cross-bedded laminae.	Anastomosing laminae with evidence of slumping in the form of recumbent laminae.
Genesis	Clastic; breakup of fine-grained calcite, some may be faecal pellets; worn pelmatozoan crystals.	Clastic; dissociation plus movement; some pelmatozoan plates may have been moved back and forth.	Probably a primary precipitate, possibly a recrystallization product.	Probably originated by dolomitization of Mg-enriched matrix calcite.	Probably originated by early replacement of intergranular matrix calcite; some replacement of sparry calcite is possible.	Quartz, feldspar, and micas detrital; overgrowths authigenic.	Genesis uncertain, structures may be due to activity of organisms (algae?) in building and binding sediment. Mineral components have variable genesis.

Table 12

Petrographic rock characteristics of subtype B-5 in sample 16113

Epler limestone, Section No. 4
Petrographic class: Bioclastic calcarenite
Genesis: Clastic
Illustrated in Plate 19, Figs. 3 and 6

Textural - Morphological Components	Sand (Grains) (includes several fragments)	Bioclastics (Grains)	Megacrystalline aggregate (Cement)
Composition	Calcite	Calcite	Calcite
Percent Slide No. 16113	35.2	10.6	54.2
Size and shape; internal organization.	Size range about 1/16-2 mm., average about 1 mm.; equant to elongate; rounded, commonly with pointed extremities; surface texture smooth where bordered by sparry shell calcite; composed of finely microcrystalline calcite.	Largely composed of fragments and scattered complete specimens of rather small gastropods with sparry calcite shell material that is probably a product of recrystallization; dusty gray, rounded pelmatozoan crystals with clear overgrowths are common.	Coarse microcrystalline to medium megacrystalline; anhedral; clear with cleavage and twinning.
Fabric relations	Moderately well-packed to floating, cemented by sparry calcite; long axes aligned at angle to bedding and parallel rock cleavage trace; enclosed in recrystallized shells.	Sparry calcite gastropod shells surround lime mud filling and locally grade into sparry cement; pelmatozoan overgrowths make up small part of sparry cement.	Interlocking crystalline; cementing sand, fragments and bioclastics; gradational with and probably includes much recrystallized shell material and pelmatozoan overgrowths.
Structural Disposition	Disseminated throughout rock.	Disseminated throughout rock.	Disseminated throughout rock.
Genesis	Clastic; gastropod cavity filling in places.	Clastic; breaking apparently accompanied movement in most cases.	May be a precipitate but may also have originated by recrystallization of carbonate mud and gastropod shells.

and variation in calcite content (Pl. 13, Figs. 5, 6).

Localized disturbances and disruptions of laminae and bands are typical. Laminated sequences commonly grade along and across bedding into mottled zones which in places take on a conglomerate-like appearan. Recumbent small-scale folds are common, over which succeeding lamina are draped. Crinkling of laminae in many zones is suggestive of that associated with some evaporite deposits. In many samples highly contorted structures are common, intersecting laminations at high angles (Pl. 13, Figs. 3-5). Laminae are commonly domed around the structur and disrupted edges of the laminae are bent upward indicating the directi of movement of the injected material. In some cases, laminae that form the "roots" of the dike-like masses commonly pinch out a short distance from the structures, indicating that injection of the material may have been caused by pressure of increasing overburden during burial. In some places the structures are somewhat similar to those described by Shrock (1948, p. 278) in specimens of "landscape" marble. For the lack of a more descriptive term they are here called "arborescent" structures although their morphology varies greatly. These delicate structures ma plausibly be attributed to the work of rising gases, liquids, or soft sediments in semi-consolidated, fine-grained "mud." Small-scale cross bedding and diastems appear to be common (Pl. 13, Fig. 4). Scour surfaces have relief ranging up to a millimeter in places.

Dolomite subtypes containing appreciable amounts of calcite are common in the Epler Formation but are not common in the Rickenbach or Ontelaunee. This group of subtypes includes B-1c, calcitic-laminated dolomite (Pl. 13, Fig. 6); B-1d, calcitic-mottled dolomite; and B-1h, "calcarenitic" dolomite (Pl. 14, Figs. 3-5). Rock of subtypes B-1c and B-1d most commonly occurs in layers; that of subtype B-1h occurs subequally in layers and in irregular patches intermixed with mottled rock.

Rock subtype B-1j includes fine-grained dolomite with chert nodules subnodules, stringers and mottling. As seen microscopically the chert is composed of microcrystalline silica, commonly enclosing dolomite euhedra (Pl. 14, Fig. 6). The enclosed dolomite crystals are generally larger and of more perfect crystal habit than the crystals making up the dolomite surrounding the chert, suggesting that they were not isolated by replacement of the dolomite rock. In one etched section the euhedra in the chert have been distorted. In several etched sections angular fragments of dolomite are enclosed in chert; and, in the field, angular chert fragments are included in dolomite.

The growth of well-formed crystals in the chert, distortion of some enclosed euhedra, and relations of the brecciated rock suggest that the dark, microcrystalline chert and dolomite of type B-1 have a common

time of origin in places.

Rock type B-2

Composition - X-ray analyses and acid etching of rock slabs indicate that rock type B-2 contains appreciable quantities of calcite. The calcite usually occurs as sparry vug-filling and as matrix between the dolomite crystals. As in the case of rock type B-1 the calcite and dolomite spacings are normal for the minerals. A special comparative X-ray study of dolomite in the two rock types indicates that the dolomite lattice spacings are identical within and between the rock types.

Texture - Textural elements in rock type B-2 are as follows in order of decreasing volumetric importance of the textural classes.

Grains: dolomite, quartz, feldspar
Matrix: opaque black matter, microcrystalline calcite
Cement: chert, clear megacrystalline calcite (vug-filling).

Crystals are typically larger than 1/4 mm. in rock type B-2. Crystals are most commonly subhedral and zoned crystals are numerous (Pl. 15). The crystals typically have straight to interpenetrating contacts, and they may be either clear of be remarkably turbid with microcrystalline inclusions. Comparison of rock types B-1 and B-2 in terms of crystal texture and fabric is provided by study of Plates 13 and 15.

Relict textures - In many samples of rock type B-2, numerous darker spots and specks are common. The spots are commonly of the order of one-fourth to one-half millimeter in diameter but may be as large as five to ten millimeters. Megascopically, the darker areas resemble sand and granules enclosed in lighter colored cement. The texture characterized by these spots is termed paradoloarenitic and paradolo-ruditic. Five thin sections of subtype B-2d have been studied. One of the slides displays numerous zoned crystals (Pl. 15, Fig. 5). Two of the slides contain scattered clusters of highly birefringent inclusions in the dolomite (Pl. 15, Figs. 1-3). The clusters, rounded and subequant with rather distinct outlines, are commonly shared by several dolomite crystals. These groups of inclusions appear to be remnants of clastic grains, plausibly of calcite, which have been replaced by dolomite. Pelmatozoan plates are typically quite "dusty" and may leave traces where dolomitized. Long, slender and curved rows of sparry dolomite associated with the clusters may represent replaced shells. Two of the above-mentioned slides contain irregular, equant to elongate, fragment-like clusters of anhedral, finely megacrystalline dolomite that are arranged subparallel to bedding (Pl. 15, Fig. 4). The clusters are surrounded by coarser, sparry crystals of dolomite which apparently transect the "fragment"

boundaries in places. In some cases the fragment-like patches appear to have clusters of silt- and fine-sand-sized inclusions. The texture of the dolomite within the fragment-like patches and the shape and surface morphology of the patches are suggestive of incompletely dolomitized fragments of "algal" limestone found in "channels" in the Stonehenge (see detailed petrography of rock type B-5). It is not known whether the fragment-like clusters are due to: (1) breakup of dolomitized sediment and later cementation by sparry dolomite, (2) replacement of limestone fragments and clear cement, resulting in different textures, or (3) a combination of (1) and (2).

Dolomitic mottling and shells replaced by dolomite characterize the almost completely dolomitized limestone in the lower member of the Rickenbach in central Berks County (Pl. 16, Fig. 5). In thin section, the dolomite crystals are subhedra and euhedra, of medium megacrystall texture, and are turbid with microcrystalline inclusions (Pl. 15, Fig. 6). Zoned crystals are common. The host limestone is calcilutite lacking a clearly defined clastic texture that could be inherited as relict grains by the dolomite.

<u>Structure</u> - The following structures have been recognized in samples of rock type B-2:

A. Laminae and bands
   1. irregular and discontinuous, subparallel laminae and bands

B. Mottling
   1. color mottling
   2. siliceous mottling (mostly cherty)

C. Chert subnodules and "cauliflower" masses

D. "Micro-fractures"

E. "Vugs"

The absence of delicate structures, such as thin laminae described in rock type B-1, is most striking. In contrast to the regularly laminate aspect of rock subtype B-1b, the laminae in rock subtypes B-2b and B-2c are irregular and discontinuous. Tightly cemented quartz and feldspar, microcrystalline chert or carbonaceous matter make up most of the structures.

Chert subnodules, "cauliflower" masses and "rosettes" are commo in beds of rock type B-2. The "rosettes" are nests of light-colored,

chalcedonic quartz in which crystals radiate from closely spaced centers and surround patches of dolomite in which the crystals are texturally similar to those making up the dolomite surrounding the nests. The quartz-dolomite interfaces are transitional zones with complex intergrowths of silica and dolomite. The radiating nature of the crystals and the presence of engulfed dolomite suggest that the chert and quartz formed by replacement of the dolomite.

Small, irregularly tapering "microfractures" commonly found in rock type B-2 and distinguishing subtypes B-2e have been described megascopically in foregoing chapters concerned with the petrology of the Rickenbach in central Berks County. Under the microscope these structures are seen as irregular fractures filled with clear, sparry dolomite and possessing rather distinct outlines. In a number of cases the sparry crystals are optically continuous with crystals making up the walls of the fracture. The arrangement of the fractures, most often apparently random but also parallel and perpendicular to bedding, their small size, and their irregular tapering shape suggest that they may be due to shrinkage of partially consolidated sediment. In one sample they are associated with "relict" textures and in all but a few samples they are confined to dolomite of medium or coarse crystallinity. They suggest that in some cases dolomitization proceeded beyond the sediment, filling in fracture voids unless, of course, the fractures had been previously filled with sparry calcite.

The etching action of most samples of type B-2 in dilute HCl reveals a patchy and intergranular distribution of calcite (Pl. 16, Figs. 1-4). Etching of small dolomite plugs of type B-2 have resulted in increases of permeability up to several hundred times (Hobson, 1961). The calcite occurs as vug-filling, microcrystalline patches, and matrix surrounding the dolomite crystals.

Genesis of rock types

The contrast in composition, texture, and structure between rock types B-1 and B-2 indicates strongly different sets of genetic conditions. The probable genesis of each of the two types is discussed in the chapter concerned with interpretation of lithofacies types. It is believed that dolomite of type B-1 has been deposited on the sea floor as a precipitate or has resulted from penecontemporaneous replacement of sediment. The associated dark-colored, fine-grained cherts are also considered to be penecontemporaneous with deposition in most cases. In contrast, dolomite rock type B-2 is believed to have resulted from replacement of limestone at a later stage of diagenesis for the most part. The "cauliflower" chert and "rosettes" are also considered to be late diagenetic, following dolomitization at various stages of diagenesis, yet the contrast

of rock types B-1 and B-2 suggests two predominant stages of dolomite formation.

Limestone Rock Types

Introduction

Four major limestone rock types and subtypes have been recognize[d] in the study. The limestone types and subtypes are listed below.

Limestone	(B-3),	smoothly fracturing cryptogranular:
	(B-3a),	apparently structureless
	(B-3b),	dolomitic-mottled
	(B-3c),	silty-argillaceous-laminated and dolomitic-mottled
	(B-3d),	siliceous-laminated and -mottled and dolomitic-mottled
Limestone	(B-4),	roughly fracturing cryptogranular:
	(B-4a),	silty-laminated and siliceous-laminated and -mottled
	(B-4b),	dolomitic-mottled
	(B-4c),	dolomitic-laminated and -banded
	(B-4d),	silty-argillaceous-laminated
Limestone	(B-5),	calcarenitic, medium to coarsely megacrystalline:
	(B-5a),	dolomitic-laminated and -banded
	(B-5b),	dolomitic-mottled
	(B-5c),	silty-argillaceous-laminated
Limestone	(B-6),	calciruditic
	(B-6a),	silty-argillaceous-laminated
	(B-6b),	dolomitic-mottled

Rock type B-3

Although about 21 percent of the lower one-half of the Epler Formation and 85 percent of the upper member of the Stonehenge in central Berks County are composed of limestone classed as smoothly fracturing cryptogranular, only two samples of subtypes B-3a, B-3b, and B-3c fron these rocks are made up completely of unfragmented, microcrystalline or submicrocrystalline calcite. Examples of rock type B-3 are shown in Plate 17. Of the subtypes, B-3b and B-3c are perhaps the most common. Subtype B-3c is composed of the following textural elements

listed in order of decreasing proportion of the main textural classes.

Inter-laminae areas:

Matrix:	microcrystalline calcite, clays
Grains:	bioclastics, irregularly shaped and subspherical fragments of micro-crystalline and submicrocrystalline calcite, dolomite, unit crystalline calcite, pyrite
Cement:	megacrystalline calcite

Irregular, stylolitic laminae:

Grains:	quartz, twinned feldspar, dolomite, pyrite
Matrix:	clay (limonitic-stained).

Components of subtype B-3c from the Stonehenge are listed and described in more detail in Table 8 and of subtype B-3a from the Epler in Table 9.

The major part of rock type B-3 is made up of crystals unresolvable at moderate magnifications of about X50. Within a thin section and with complete transition, submicrocrystalline calcite grades into patches of microcrystalline and megacrystalline calcite. Where the sediment has been fragmented, calcite within the fragments is finer grained than that around the fragments (Pl. 17, Figs. 2-5). Commonly a bioclastic component is scattered throughout the matrix in parts of the rock (Pl. 17, Figs. 2-5). Brachiopod shells and pelmatozoan plates are abundant in rock type B-3 in the Stonehenge. Gastropods are more common in the rock type in the Epler, implying a somewhat different genesis for the rock type from that in the Stonehenge. In the Stonehenge, the brachiopod valves, though disarticulated, are characteristically neither broken nor worn and appear most often to be randomly oriented. Shell cavities have been filled with lime "mud" or with megacrystalline calcite.

Vein-filled cavities are common in the lime "mud". The vein material is megacrystalline calcite. In one slide, fragments of mud and a pelmatozoan crystal lie on the bottom surface of a cavity filled with sparry calcite (Pl. 17, Fig. 6). Clastic debris at the base of such structures has been cited by Sander (1951) as evidence of the existence of a cavity prior to deposition of sparry calcite as well as a valuable top and bottom indicator. The precise time of origin of these cavities is not known. It has been suggested, most plausibly, that the structures formed during early diagenesis when carbonate-charged waters fill cavities in soft mud and precipitate large, clear crystals of calcite before a crushing

action by increased overburden is brought to bear on the sediment (F. M. Swartz, pers. comm.).

Dolomite occurs in rock type B-3 as scattered euhedral crystals and as clusters of crystals contained in irregular lenses and in clayey, silty and stylolitic laminae (Pl. 17, Figs. 1-3). Dolomite is also commo in structures attributed directly or indirectly to plants or animals. The more common of the structures, so-called "fucoids," consist of cylindri or tubular structures overlapping and anastomosing in complex fashion. The shape of the fucoids suggests they are the product of boring organis in some places and in others they seem to be more likely the remains of plants. The dolomite may have been formed by selective dolomitization of sediment enriched in magnesium by organic agents.

Dolomitized stromatolites of the cryptozoon and gymnosolen type are visible in many beds composed of rock type B-3. Rather indistinct gymnosolen-type stromalites may be seen in outcrops in the upper meml of the Stonehenge of Berks County (Pl. 17, Fig. 1). They are also reported from the Beekmantown of southern Pennsylvania and of Marylar (Sando, 1957, 1958). Cloud (1942) and Sando compare the structures to those of blue-green or green algae common in modern sediments.

Rock subtype B-3d is characterized by a rather peculiar but distinctive appearance (Pl. 18, Figs. 1-3). In most cases subtype B-3d is intimately associated with subtype B-4a. The structures and containe textural elements of subtype B-3d are listed as follows:

Lenses and discontinuous bands:

Matrix:	finely microcrystalline to submicrocrystalline calcite
Cement:	megacrystalline calcite
Grains:	bioclastics including pelmatozoans, fragments of matrix calcite

Irregular laminae and mottling:

Dark, microcrystalline complex of chert and carbonates with quartz and feldspar grains, clay minerals, and micas, pyrite, and alteration products.

The components of subtype B-3d are listed and described in more detail in Table 10. The following discussion is concerned mainly with th make-up of the siliceous structures.

In etched section and the naturally weathered rock, the siliceous

laminae and mottling exhibit strong relief and are hard, flinty structures that scratch metal readily and break into sharply edged fragments. Acid attack is pronounced along the edges of the structures where the calcite parts dissolve leaving a siliceous network in a zone about 1/2 to 1 mm. thick (Pl. 18, Fig. 1). Thin laminae within the siliceous structures are due to varying proportions of the mineralogic components.

Thin section examination reveals a dense network of cloudy to opaque material with low birefringence intermixed with carbonate and surrounding quartz and feldspar grains and micas (Pl. 18, Fig. 2). Pyrite and pyrite altered to limonite are common. The dark color may be due in part to carbonaceous matter. X-ray analysis of relatively fresh parts of the structures reveals the presence of calcite, quartz, clay minerals (sharp peak at about 7 Å and a broad, poorly defined peak at about 10 Å), and feldspar.

Rock type B-4

As studied in the laboratory, rock type B-4, roughly fracturing cryptogranular limestone, is most often composed of calcisiltite and fine calcarenite. The major textural elements in subtype B-4a and B-4c are listed as follows:

Irregular bands:

Grains: round "pellets", bioclastics, quartz and feldspar, micas, dolomite
Cement: coarsely microcrystalline or finely megacrystalline calcite, dolomite

Thin laminae, cross-bedded in places:

Grains: round "pellets", quartz, and feldspar
Cement: calcite, dolomite

Regular bands: dolomite

Irregular, anastomosing laminae and bands:
Dark, microcrystalline complex essentially identical to that described in rock subtype B-3d.

The components of subtype B-4a are listed and described in more detail in Table 11. Discussion of the internal characteristics of the irregular, cherty laminae and bands has been made for rock type B-3d. The following is concerned chiefly with components in the non-siliceous

laminae and bands.

Spherical grains of microcrystalline and submicrocrystalline calcite about 1/64 to 1/10 mm. across, and megacrystalline to coarsely microcrystalline calcite cement (and matrix) are the predominant constituents in the calcite bands of subtype B-4a and B-4c (Pl. 18, Figs. 4-6). The calcite grains are evenly dispersed and vary from loosely to moderately well packed. Although composed in most cases of submicrocrystalline calcite, the "pellets" are rounded, "dusty" crystals in places, resembling crinoid fragments that have been worn. Many of the crystal grains are surrounded by optically continuous cementing crystals of clear calcite. Quartz and feldspar grains are intermixed with the calcite grains and are concentrated in silty, cross-bedded laminae in many places (Pl. 18, Fig. 4). The calcite and quartz grains are cemented by sparry dolomite, in a patchy distribution, as well as by calcite. Where the rock is banded with dolomite, it is classed as subtype B-4c. The quartz grains associated with rock type B-4 occur typically as doubly terminated, well-formed crystals.

Subtypes B-4a and B-3d differ from one another in the following respects although they both contain siliceous structures and occur together: (1) Subtype B-4a has a greater proportion of clastic components including detrital minerals in the carbonate bands; (2) Subtype B-3d lacks silty, cross-bedded laminae characteristic of subtype B-4a; and (3) The siliceous structures in subtype B-4a are of more regular thickness and morphology than those in subtype B-3d.

Cross-beds, worn crinoid crystals, and abundant quartz, feldspar, and mica indicate water movement during deposition of rock type B-4, therefore it is suggested that the calcite "pellets" may also be partly of clastic origin or may have been moved about by moving waters. They may also be faecal matter or be due to reorganization of the sediment during diagenesis.

Fragmental-limestone Types

Lithologic types classed as types B-5, calcarenite, and B-6 calcirudite, are termed fragmental limestones inasmuch as they are composed of megascopically visible fragments of limestone. It is understood in doing this that much of the cryptogranular rock as seen microscopically is composed of fragmental material. Fragmental limestones are composed of calcite silt, sand, conglomerate, bioclastics, and matrix cemented by sparry calcite. True calcarenite, with more than 50 percent by area (point count) of sand-sized particles of calcite, is uncommon in the rocks studied. All of the fragmental limestones are composed of a mixture of components listed above. If the percentage is estimated on the basis of the number of grains in each size, it is likely that the majority of the

samples would fall into the calcarenite category, some being silty and others conglomeratic or in some poorly sorted samples both silty and conglomeratic.

About 15 percent of the upper member of the Stonehenge is composed of rocks of subtype B-5b. The textural elements in subtype B-5b as studied from the Stonehenge are listed as follows:

Grains:	equant to platy and irregular fragments of submicrocrystalline calcite, bioclastics, dolomite
Cement:	megacrystalline calcite
Matrix:	microcrystalline calcite.

The components of subtype B-5b in a sample of Epler limestone are listed and described in greater detail in Table 12. The following is concerned with various aspects of the components as studied megascopically.

The fragments and brachiopod shells, cemented by sparry calcite, are generally subparallel to bedding (Pls. 19, 20).

The uneven surface texture of the fragments in the "channels" of the upper member of the Stonehenge (Pl. 19, Figs. 1, 2) is similar to that of the fragments described in rock type B-3c from the upper member, although the boundaries of those in the channels are more definitely defined. The fragments of fine-grained calcite characteristically contain anhedral and subhedral crystals of dolomite which in places are rounded along and in conformance with the fragment-cement interface. The crystals, commonly stained brownish around the edges, are concentrated generally in small clusters which do not extend beyond the fragment edges. It is not certain whether this restriction of dolomite to the fragment is due to wear or solution of previously dolomitized fragments or to development of dolomite closely controlled by the constituent material of the fragment.

Samples 16113 and 16-Cl-1, obtained from 305-1/2 feet and 396-1/2 feet above the base of the Epler, are typical of the samples with a large percentage of calcite sand in that formation (Pl. 19, Figs. 3, 4). The textural elements in these samples are listed as follows:

Grains:	calcite sand, bioclastics, dolomite
Cement:	sparry calcite
Matrix:	microcrystalline calcite, argillaceous matter.

The components in sample 16-Cl-1 are listed and described in Table 13.

The majority of the clastic grains in No. 16113 appear to be broken shell fillings, the size and morphology of the particles having been governed b the enclosing shells. In contrast, a sample, No. 1697, obtained about 249-1/2 feet above the base of the lower member of the Epler at Epler School, contains an appreciable proportion of calcite sand that is apparer the result of breakup of lime mud in part rather than of filling of shell cavities. The following textural elements in sample No. 1697, which is classed as a sandy calcilutite in thin section, are listed as follows:

Irregular bands:

Matrix:	submicrocrystalline calcite, argillaceous matter
Grains:	calcite sand, bioclastics, dolomite, quartz, and feldspar

Irregular laminae:

Matrix:	submicrocrystalline calcite, argillaceous matter (relatively concentrated)
Grains:	dolomite, pyrite, and alteration products, quartz and feldspar.

The components have been described in greater detail in the foregoing Table 9.

Rocks with an appreciable content of calcite fragments and pebbles of rudite size are especially common in the lower and middle members of the Stonehenge and upper member of the Epler.

In the Stonehenge, limestone conglomerate or calcirudite (rock type B-6) makes up about 15 percent of the middle member. The calcirudite is silty argillaceous laminated (subtype B-6a) and dolomitic mottled (subtype B-6b). Rock subtypes B-6a and B-6b contain the following textural elements listed in general order of decreasing importance.

Bands and beds:

Grains:	platy subrounded fragments, subspherical grains, bioclastics, dolomite (in lenses)
Cement:	megacrystalline calcite and dolomite (interfragmental)

Irregular laminae:

Grains: dolomite, quartz
Matrix: microcrystalline calcite, iron-stained argillaceous matter.

The components of rock type B-6 are listed in more detail in Table 14, and are pictured in Plate 20.

As studied principally from the the Stonehenge, the limestone fragments of rudite size, the predominant morphological component in subtypes B-6a and B-6b, are composed of: (1) submicrocrystalline to finely microcrystalline calcite, (2) conglomerate and coarse calcarenite, and (3) silt-laminated calcisiltite and silty fine calcarenite. Type (3) makes up an estimated 80 percent or more of the total number of rudite-sized fragments observed in the Stonehenge exclusive of the upper member. The internal make-up of these fragments is indistinguishable from that of the calcite bands in subtypes B-4a and B-4c. Evidence for three stages of penecontemporaneous disturbance by fracturing similar to those described by Krynine (pers. comm.) are visible in the etched sections. The following stages and their characteristics are from Krynine.

Stage 1. Rupture of layers with horizontal separation of individual parts. The corners of the fragments may vary from rounded (solution?) to angular at this stage. Disturbance within layer defines this stage which is rare in rock type B-6.

Stage 2. Horizontal displacement of fragments and imbrication; pieces still occupy essentially the position of the original layer. Disturbance and partial destruction of layer is characteristic. This appears to be the stage best represented in rock type B-6.

Stage 3. Fragments bear no relation to original layers in position or orientation. Destruction of the layer is characteristic. This stage is common in rock type B-6.

Stage 4. Fragments break into pieces which are carried away (4a) or layer is reduced in size to very fine particles, "cloud," which drift away (4b).

Formation samples No. 16187 and No. 16215, from 143-1/2 feet and 269-1/2 feet above the base of the Epler at Epler School, are characteristic of rock type B-6 in that formation. The textural elements in these samples are listed as follows, in general order of decreasing volumetric importance:

Grains: elongate fragments, calcite sand, bioclastics, dolomite

Cement: sparry calcite
Matrix: microcrystalline calcite.

The components are described in greater detail in Table 14 and are pictured in Plate 20, Figs. 3-6. The rocks classed as rock type B-6 in the Epler are essentially similar to those included in this class from the Stonehenge limestone although the platy morphology of the rudite-sized fragments is not so well developed.

Dolomitic-mottled limestone Subtypes

Mottles of dolomite, making up less than 50 percent of the surface area, characterize rocks classed as subtypes B-3b, B-4b, B-5b, and B-6b, the position of the rock in the rock-type categories depending on the apparent grain size of the calcite fraction. The mottling, similar in make-up in all the subtypes, is composed invariably of very finely megacrystalline, equigranular dolomite in anhedral to subhedral crystal grains with limonitic staining. Dolomite euhedra commonly occur in transition zones between the dolomite mottles and the calcite fraction. The morphology of the mottling is quite variable (Pl. 21).

The same mottled rock may take on several radically different aspects depending on the direction from which it is viewed, making a useful classification on the basis of mottle morphology extremely difficult. Classifications of dolomite mottles on a semi-genetic, semi-morphological basis have been published by a number of workers including Birse, 1928, and Beales, 1953.

Table 13

Petrographic rock characteristics of subtype B-5a in sample 16-C-1-1

Epler Limestone Section No. 4
Petrographic class: Dolomitic calcarenite
Genetic: Clastic
Not illustrated

Petrological components	Sand and fragments (Grains)	Bioclastics (Grains)	Microcrystalline aggregate (Matrix)	Megacrystalline aggregate (Cement)	Megacrystalline aggregate (Grains)	Noncarbonate (Grains and matrix)
Composition	Calcite	Calcite	Calcite	Calcite	Dolomite	Quartz-feldspar argillaceous material calcite, pyrite limonite and hematite (?)
Percent (16-C-1-1)	37.8 (12 percent fragments)	2.8	8.8	18.3	29.1	[illegible] (low)
Size and shape, internal organization	Length of apparent long dimension 1/16-3 mm., majority of grains from 1/16-1/8 mm., fragments are elongate rounded to with pointed extremities in some cases, generally of smooth surface texture, composed of finely-microcrystalline and submicrocrystalline calcite; two fragments bordered by joined valves of ostracodes, sand grains are rounded to subangular equant oval and sausage shaped, with surface textures that are indistinct and generally fuzzy at moderate magnifications, composed of finely-microcrystalline and submicrocrystalline calcite	Trilobite and pelmatozoan fragments varying from rounded to angular, the latter commonly with dusty interiors and clear sparry calcite overgrowths; many of the pelmatozoans have a center of microcrystalline chert, two undissociated ostracode shells have been filled with lime mud.	Finely microcrystalline and submicrocrystalline; anhedral.	Coarsely microcrystalline to coarsely megacrystalline, anhedral, clear with cleavage and twinning.	Crystal size range about 1/50-1/5 mm. anhedral, dusty inclusions.	Dark, nearly opaque in transmitted light, yellowish to brownish in reflected light, appears to be a mixture of silty argillaceous material and limonite with scattered pyrite, quartz and feldspar grains
Fabric relations	Scattered fragments with apparent long axes aligned parallel to bedding are intermixed with moderately well-packed calcite sand in places, numerous apparently floating, grains of calcite sand, elongate sand grains aligned subparallel to bedding sand and fragments cemented by sparry calcite	Loosely packed, intermixed with sand and lime mud, cemented by sparry calcite.	Interlocking crystalline grading into coarsely megacrystalline calcite cement.	Interlocking crystalline, cementing grains and matrix gradational with patches of finely microcrystalline calcite; surrounds a number of floating calcite sand grains in places.	Tightly packed anhedral to floating euhedra; euhedra along borders of clusters of anhedra in places; euhedra surrounded by limonitic stained argillaceous matrix; clustered crystals with limonitic matrix.	Tightly packed complex in stylolitic lamina surrounding dolomite euhedra, intermixed with microcrystalline calcite in places
Structural relations	Scattered and disseminated through rock.	Scattered throughout rock.	Scattered patches in rock.	Scattered patches in rock.	Sub-banded lenses, bordered by stylolites in most places.	Irregular stylolitic laminae and streaks bordering dolomite lenses for the most part.
Origin	Clastic, breakup of lime mud in part, fossil fillings in part.	Clastic; dissociation plus breaking in some cases.	Probably clastic.	Authigenic precipitate or product of recrystallization of lime mud; probably precipitate in part.	Replacement of Mg-enriched matrix calcite.	Quartz and clays probably detrital, pyrite authigenic; limonite and hematite may be alteration products.

Table 14

Petrographic rock characteristics of subtypes B-6a and B-6b

Stonehenge limestone at Wyomissing, Section No. 2

Petrographic class: Sandy bioclastic calcirudite

Genesis: Clastic

Rock type illustrated in Plate 20.

Textural-Morphological Components	Fragments (includes some sand-sized material) (Grains)	Bioclastics (Grains)	Megacrystalline aggregate (Cement)	Megacrystalline aggregate (Grains and cement)	Unit crystalline (Grains)	Microcrystalline aggregate (Matrix)	Noncarbonate (Grains and matrix)
Composition	Calcite with enclosed qtz. fldsp., micas.	Calcite	Calcite	Dolomite	Dolomite	Calcite	Quartz and feldspar; argillaceous material
Percent Slide 1713	52.5	2.5 (low for rock type in general)	19.0	7.6	6.0	8.7 (high for rock type in general)	3.7
Size and shape; internal organization	Long dimensions about 1/16 mm. to 25 cm. and larger, the majority of the surface area of the rock composed of fragments larger than 2 mm.; equant to elongate and platy; angular to rounded, mostly subrounded; smooth surface texture; mostly composed of silty laminated calcisiltite but also of calcarenite and submicrocrystalline calcite; angular fragment of laminated dolomite (rock type B-1) in one slide. Length and breadth of fragments subequal and most resemble flat subcircular pebbles.	Dusty gray pelmatozoan crystals ranging from 1/16 to 2 mm. in diameter and surrounded by clear sparry calcite make up majority of bioclastics; count includes smaller (1/16-1/5 mm.) equant, rounded grains, the majority of which appear to be pelmatozoan crystals. Many sand grains have a clear sparry interior composed of a single crystal border by a rim of submicrocrystalline calcite; other small "pellets" included in count are oval to sausage-shaped and composed of submicrocrystalline calcite; fragments of broken fibrous brachiopod shells are common as well as rounded microcrystalline trilobite fragments with extinction waves.	Crystal size up to 1 mm. grading into coarsely microcrystalline; anhedral; clear with well-developed cleavage and twins.	Crystal size about 1/5 mm.; euhedral to anhedral; some with dusty centers and overgrowths.	Crystal size range about 1/30 to 1/4 mm., average about 1/6 mm.; euhedral; iron-staining throughout crystals or concentrated in dark centers surrounded by clear overgrowths.	Finely microcrystalline, average about 1/200 mm.; anhedral; commonly a darker brownish and argillaceous in vicinity of silty-argillaceous laminae.	Quartz-feldspar grains about 1/16 mm.; argillaceous matter smaller than 1/64 mm. and dark brownish to yellowish (limonitic stained).
Fabric relations	Loosely packed to tightly packed; interpenetrating along stylolitic contacts in some places, straight to touching fragment-to-fragment contacts common; variable orientations; apparent long dimensions aligned subparallel and obliquely imbricated to bedding; fragments perpendicular to bedding in places where jumbled together.	Loosely packed; intermixed with fragments and cemented by sparry calcite; pelmatozoan sand clustered in places and cemented by sparry overgrowths. Brachiopod and trilobite fragments subparallel to bedding in most instances where a preferred pebble orientation is also evident.	Interlocking crystalline, cementing fragments, sand and bioclastics; includes overgrowths on pelmatozoan debris.	Interlocking crystalline to floating crystals; clustered types with interpenetrating borders, floating types euhedral; rhombs interpenetrate sparry calcite as well as quartz and feldspar (one interpenetrated grain has polysynthetic twins); dolomite commonly concentrated along underside of larger fragments.	Loosely packed; floating in a dark argillaceous matrix which borders and grades into silty argillaceous laminae.	Interlocking crystalline; gradational through darker areas into silty-argillaceous laminae.	Quartz-feldspar grains tightly packed in argillaceous material which also encloses euhedral dolomite crystals.
Structural deposition	Disseminated throughout rock which occurs in thin beds and in lenses.	Disseminated, scattered and clustered throughout rock.	Disseminated throughout rock.	Lenses and patches.	Scattered throughout irregular silty-argillaceous laminae.	Irregular laminae.	Irregular laminae.
Genesis	Clastic; largely by breakup of subtype B-6a, possible wave action following mud-flat conditions.	Clastic; dissociation plus strong movement and breaking of valves; rounding.	Possibly chemical precipitate or product of recrystallization.	Replacement of interfragmental material.	Replacement of Mg-enriched matrix.	Nonclastic (?)	Quartz and clays probably detrital.

Table 15. *Scheme for description of carbonate textures.*

Wentworth grade scale (mm)	Crystallinity (reflecting faces)	Clastic grain size (after Grabau, 1924, p. 294)	Morphological and textural Modifiers		Texture as estimated on broken surfaces where clastic grains are not apparent.
4096.0 – 2.0	Megascopic: Very coarsely megacrystalline (plus statement of estimated grain size)	Megascopic: Calcirudite (dolorudite)	Fragmental limestone: Sandy or silty > 10% sand, silt,		Grain size usually discernable megascopically, whether clastic or crystalline.
2.0 – 1.0		Very coarse calcarenite (doloarenite)	Pebbly or silty > 10% pebbles, silt	Oolitic, Bioclastic, Sparry, Crinoidal, etc.	
1.0 – ½	Coarsely megacrystalline	Coarse calcarenite (doloarenite)			
½ – ¼	Medium megacrystalline	Medium calcarenite (doloarenite)			
¼ – ⅛	Finely megacrystalline	Fine calcarenite (doloarenite)			Megascopic: Roughly fracturing cryptogranular (irregular fracture with silty-appearing surface)
⅛ – 1/16	Very finely megacrystalline	Very fine calcarenite (doloarenite)			
1/16 – 1/64	Megascopic / Microscopic — Microcrystalline: Coarsely	Calcisiltite (dolasiltite)	Sandy or pebbly, > 10% sand, pebbles		
1/64 – 1/256	Finely				
below 1/256	Sub-microcrystalline	Calcilutite (dolalutite) (may or may not be clastic)			Smoothly fracturing cryptogranular (smooth, curved fracture)

PLATE 13

Figures 1, 2.—Thin section views of dolomite rock type B-1 showing characteristic texture and fabric. Note laminae of finer crystals in Figure 1 and scattered larger crystals in a microcrystalline matrix in Figure 2. Crystal habit is typically anhedral. Dark spots in Figure 2 are pyrite. Figure 1 of sample 113, lower member of the Stonehenge at Glenside, section No. 1; Figure 2 is of sample 164, from the upper member of the Rickenbach Formation at Epler School, section No. 3.

Figures 3-5.—Acid etched surfaces of rock of subtype B-1b, laminated, microcrystalline to very finely megacrystalline dolomite. Darker laminae are due in large part to a greater proportion of limonitic matrix. The etched sections show "arborescent" structures described in the text as being typical of rock type B-1. Disturbance of the thin lamina is typical and small-scale cross-bedding is visible in the upper left of Fig. 4. Nature of structures indicates movement of soft sediments after formation of the dolomite. It does not seem likely that later dolomitization would preserve such delicate features of the rock. Lighter colored laminae in Figure 5 appear to be relatively calcareous; lamina at base of "aborescent" structures in Figure 5 appears to pinch out away from structure. Figure 3 is of sample 16173 and Figure 4 of sample 16182 from 498-½ feet and 535-½ feet respectively above the base of the Epler Formation at Epler School, section No. 4; Figure 5 of sample 165 from 29-½ feet above the base of the Rickenbach Dolomite at Epler School, section No. 3.

Figure 6.—Acid etched surface of rock of subtype B-1c, calcite-laminated dolomite. Laminae consist of dolomite, calcite and mixtures of the two. Sample 16184 (?) from 550 feet above the base of the Epler Formation at Epler School, section No. 4.

Figure 7.—Acid etched surface of rock of subtype B-le, mottled, very finely to finely megacrystalline dolomite. Mottling is apparently due to variable amounts of darker matrix between crystals and is apparently the result of a slumping action in soft sediment. Sample 163 from 28-½ feet above the base of the upper member of Rickenbach Dolomite at Epler School, section No. 3.

PLATE 14

Figures 1, 2—Thin section of rock subtype B-1f, siliceous-laminated dolomite reveals that in some samples the siliceous laminae are composed in great part of quartz and feldspar silt. Several twinned feldspar grains may be seen in Figure 2. Sample RRX-8 from 8 feet below the top of the lower member of Rickenbach Dolomite at Rickenbach, section No. 2.

Figures 3, 4.—"Floating" grains of quartz sand are common in a 100-foot zone in the upper member of Rickenbach Dolomite. The grains are round and spherical for the most part. The round grains of microcrystalline carbonate intermixed with the quartz grains in this sample are mixtures of calcite and dolomite, as indicated by selective solution on the acid-etched surface shown in Figure 3. Sample 1624 from 96-½ feet above the base of the upper member of the Rickenbach Dolomite at Epler School, section No. 3.

Figure 5.—Acid-etched surface of rock of subtype B-1h, calcarenitic dolomite, showing round calcite sand grains enclosed in very finely megacrystalline dolomite. Fossil fragments are very common in the subtype. Features may be explained by mixing of clastic particles with dolomite "mud" or by selective dolomization of relatively permeable matrix between grains. Sample 1671 from 175-½ feet above the base of Epler Formation at Epler School, section No. 4.

Figure 6.—Contact in thin section between stringer of microcrystalline silica (chert) and dolomite. Chert is texturally identical to that found in nodules, stringers, some mottlings, and beds of chert associated in most cases with dolomite of rock type B-1. Note larger size of dolomite crystals adjacent to chert structure. Sample 1525 from 107 feet below top of lower member of Rickenbach Dolomite at Rickenbach, section No. 2.

PLATE 13

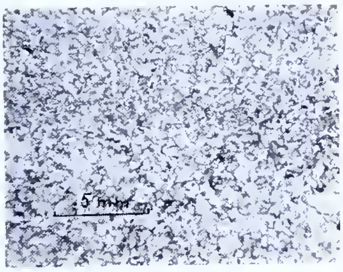


Figure 1

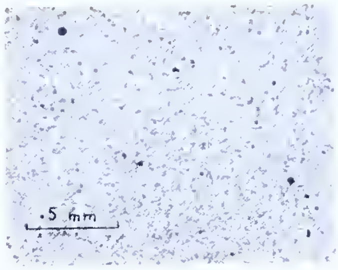


Figure 2

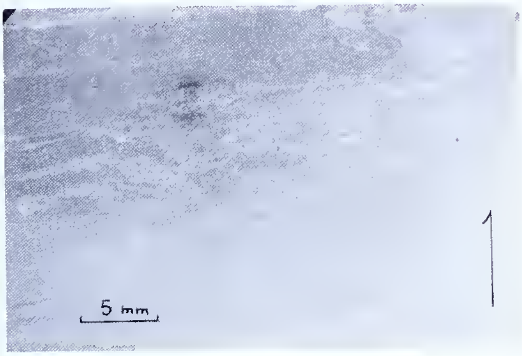


Figure 3

Figure 5

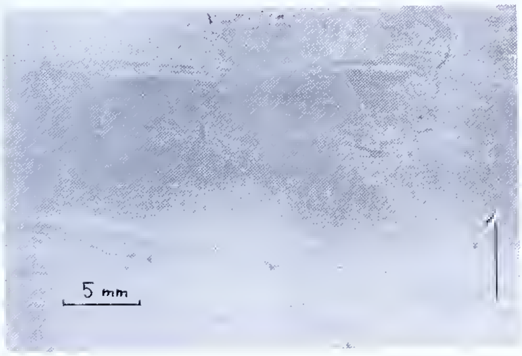


Figure 4

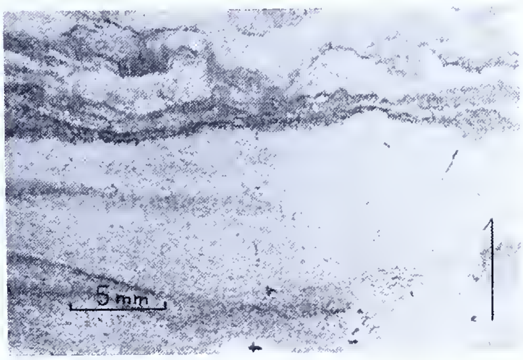


Figure 7

Figure 6

PLATE 14

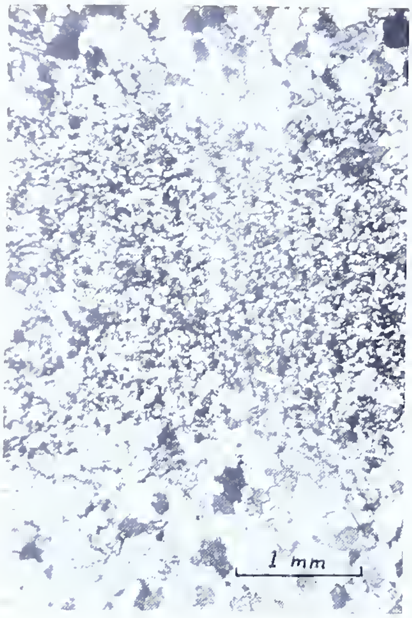


Figure 1

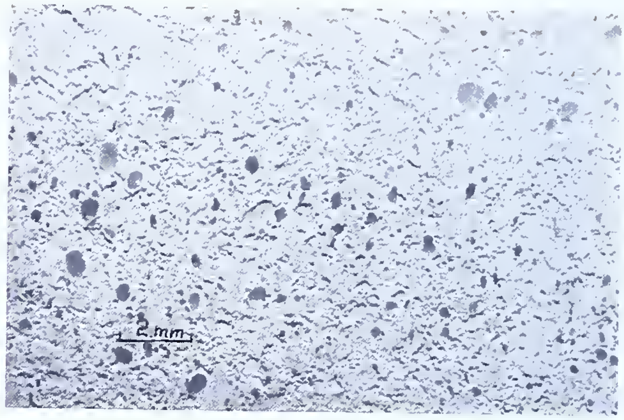


Figure 3

Figure 2

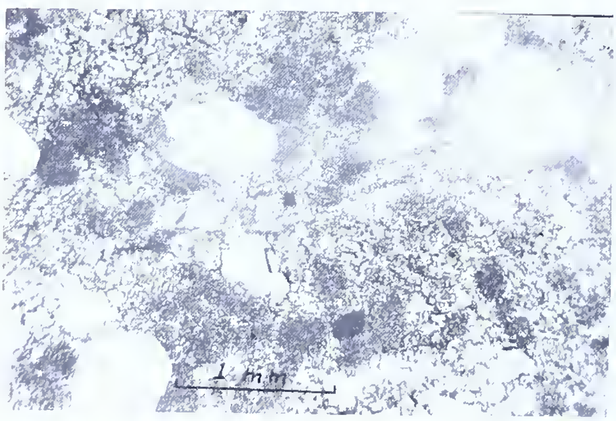


Figure 4

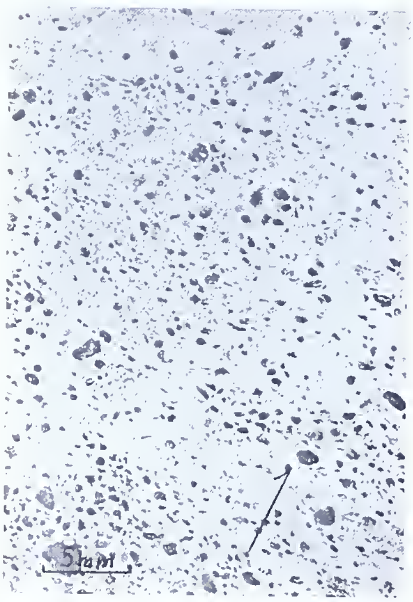


Figure 5

Figure 6

PLATE 15

Figures 1, 2.—Thin section views of rock of subtype B-2d, para-doloarenitic dolomite, showing clusters of finely microcrystalline inclusions (arrows). Clusters are rounded and equant and are shared in some places by several crystal grains. Clusters are believed to be relict or "ghost" grains of clastic carbonate, possibly calcite. Sample 1516 from 24 feet below top of the lower member of Rickenbach Formation at Rickenbach, section No. 2. Figure 1 is view between crossed nicols, Figure 2 in plain polarized light.

Figure 3.—Thin section view of rock of subtype B-2e, "microfractured", medium megacrystalline dolomite. Sparry dolomite fills "microfracture" and is surrounded by crystals that are cloudy with inclusions. Small clusters of inclusions may be relict clastic grains. In lower left corner of photograph a cluster of inclusions appears to be shared by the clear dolomite (arrow). Sample 1525 from 107-½ feet below top of lower member of Rickenbach Dolomite at Rickenbach, section No. 2.

Figure 4.—Thin section view of rock of subtype B-2d, para-doloarenitic dolomite showing "fragments" made up of anhedral, limonitic-coated dolomite crystals. The "fragments" are cemented by clear subhedral crystals of dolomite. Edges of the "fragments" transect single crystals in places (arrow). Elongate "fragments" are aligned subparallel to bedding. In some samples the "fragments" display small specks suggestive of relict calcisiltite or very fine calcarenite. Sample 1237 from 59-½ feet below the top of the lower member of Rickenbach Dolomite at Wyomissing, section No. 11.

Figure 5.—Thin section view of rock of subtype B-2d, para-doloarenitic dolomite. The arenitic appearance on the fresh surface is apparently due to the dark centers of zoned euhedra and subhedra, enclosed in lighter colored dolomite. Sample 1529 from 129-½ feet below upper contact of the lower member of Rickenbach Dolomite at Rickenbach, section No. 2.

Figure 6.—Thin section view of rock of subtype B-3b, dolomitic-mottled limestone. Dolomite crystals are subhedral and filled with submicrocrystalline inclusions. Some crystals show zoning. The dolomite is limonitic stained and limonitic-stained calcite borders the dolomite mottles and surrounds small clusters of dolomite crystals. Poorly formed, indistinct dolomite crystals form a transition zone between the calcite and dolomite rock. The limestone has an indistinct fragmental appearance in places. Sample 1247 from 127 feet above the base of the Rickenbach Dolomite at Wyomissing, section No. 11.

PLATE 16

Figures 1 - 3.—Acid etched surfaces of rock of subtypes B-2a and B-2c showing porosity caused by selective solution of the calcitic parts. Dark, cherty laminae as in Figure 3 are commonly the only stratification markers in rock of this type. Chert encloses euhedra of dolomite, of which many are distorted and elongated sub-parallel to the laminae edges. Figure 1 of sample 1242, Figure 2 of 1252, and Figure 5 of 1234, 99-½ feet, 127 feet, and 48-½ feet respectively above the base of the lower member of Rickenbach Dolomite at Wyomissing, section No. 11.

Figure 4.—Acid etched surface of rock of subtype B-2c, irregularly laminated, fine-to-medium-megacrystalline dolomite. Dark laminae are due to dull gray matrix between larger crystals and to inclusions within crystals. Lamina at top is broken and faulted. Rock shows pitted surface caused by selective solution in the acid. Sample 1526 from 208-½ feet below top of the lower member of Rickenbach Dolomite at Rickenbach, section No. 2.

Figure 5.—Acid etched surface of sample shown in thin section as Figure 6, Plate 15. Shell-like forms are visible; the outcrop contains two dolomitized gastropods and a cephalopod.

PLATE 15

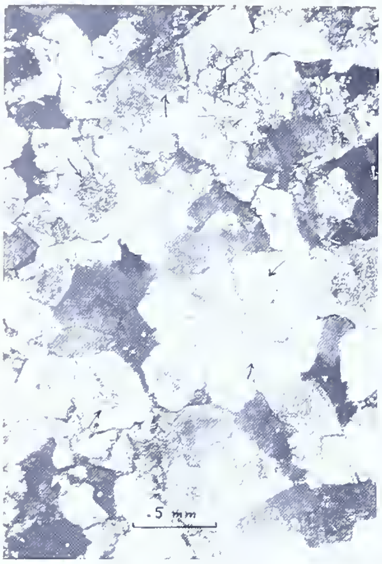


Figure 1

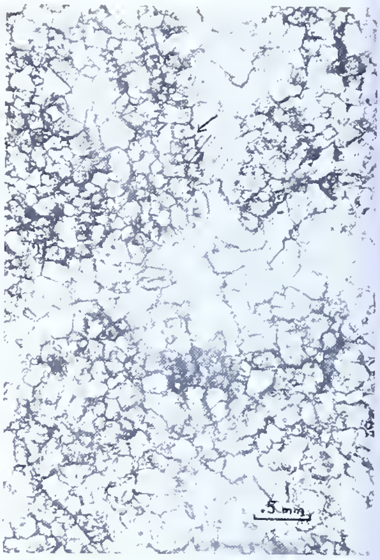


Figure 4

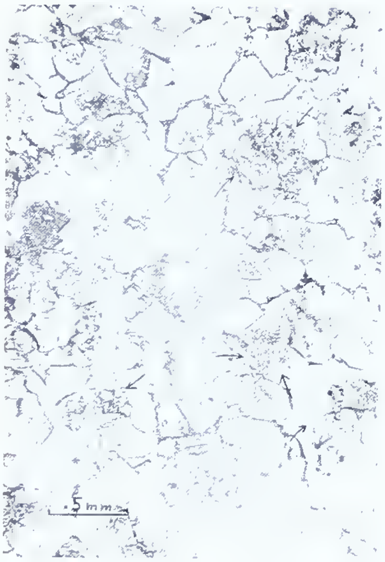


Figure 2

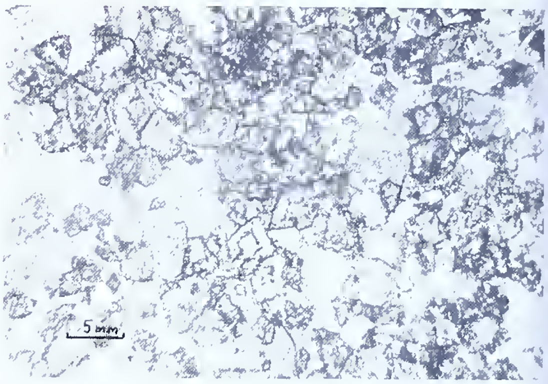


Figure 5

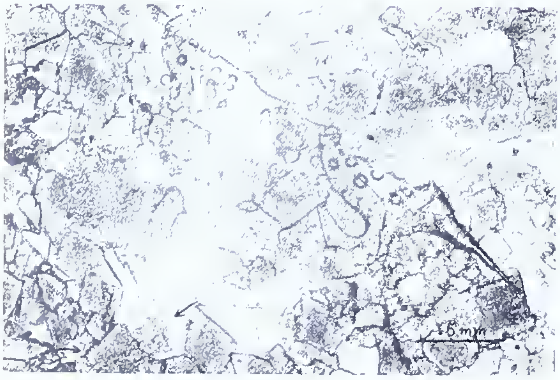


Figure 3

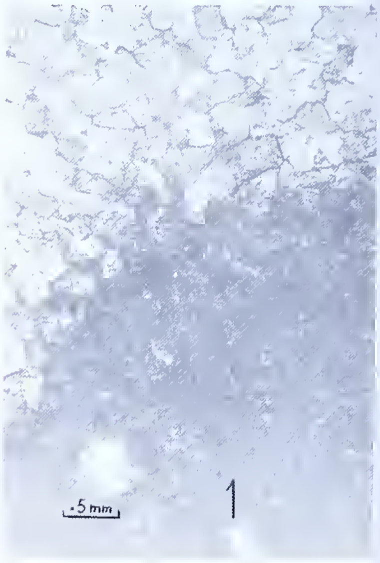


Figure 6

PLATE 16

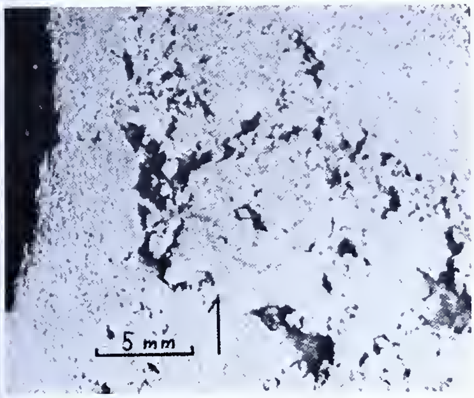


Figure 1

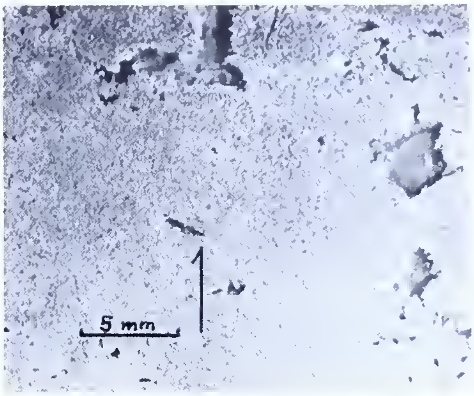


Figure 2

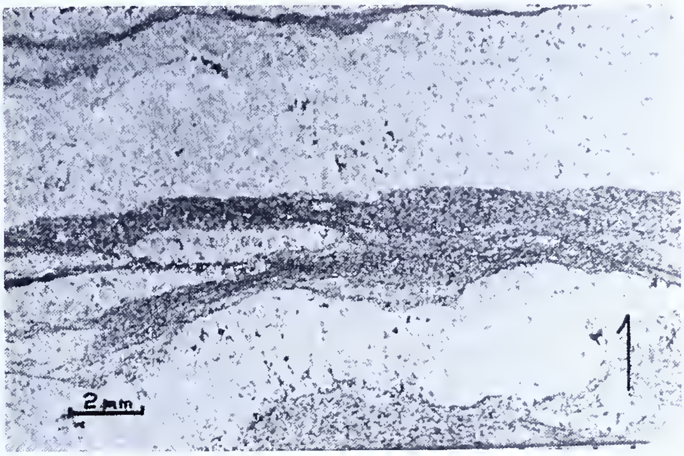


Figure 3

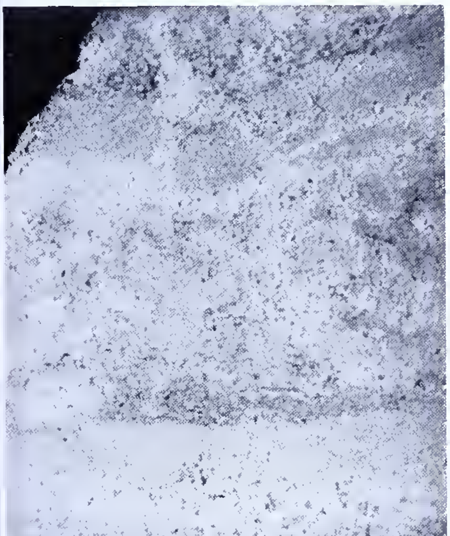


Figure 4

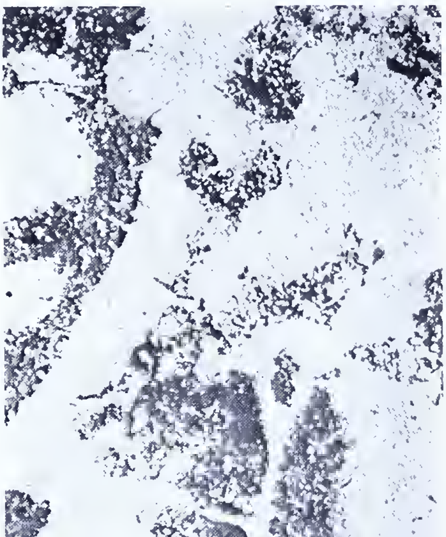


Figure 5

PLATE 17

Figure 1.—Acid etched surface of rock of subtype B-3c. Light-colored dolomite outlines indistinct structure resembling stromatolite. The structures may be seen also in field exposures of the upper member of the Stonehenge and have been distorted parallel to a poorly defined rock cleavage in places. Sample 1121 from the upper member of Stonehenge Limestone at Glenside, section No. 1.

Figures 2, 3.—Thin section views of rock type B-3c in the Stonehenge showing common disposition of dolomite. Subhedral and euhedral dolomite crystals occur in lenses and in silty-argillaceous laminae. The laminae appear in some samples to be stylolitic in part as evidenced by truncation of fossils and calcite-filled fractures (Fig. 2), Sample 1122.

Figures 4, 5.—Thin section views of clastic lenses in rock of subtype B-3c in the Stonehenge. Lenses are in rock of subtype B-3c in the Stonehenge. Lenses are made up of clastic grains of submicrocrystalline calcite, pelmatozoan plates, trilobite fragments, and brachiopod shells in a matrix of coarsely microcrystalline calcite. The limestone fragments have an irregular surface texture (compare with those in Plate 19, Figs. 1, 2) and a jumbled arrangement. The largest fragment in Figure 4 has a "core" of limonitic staining that parallels the edge of the fragment. Sample 1122 from the upper member of Stonehenge Limestone at Glenside, section No. 1.

Figure 6.—Thin section view of limestone pebble in rock of type B-6 containing a cavity filled with megacrystalline calcite. Existence of cavity is indicated by clastic debris, partially cut off by lower edge of photograph, which probably came to rest before formation of megacrystalline calcite. Sample 115, 6 feet below top of lower member of Stonehenge Limestone at Glenside, section No. 1.

PLATE 18

Figures 1, 2.—Etched surface and thin section views of rock of subtype B-3d showing anastomosing laminae and subreticulate mottles of silica-cemented material surrounding lenses of submicrocrystalline matrix and lenses of fragmental or clastic limestone. The laminae and mottles are characterized by a thin light and dark internal stratification and the borders of the structures in Figure 1 show the effect of selective solution of calcite which leaves a siliceous network. The internal characteristics of the siliceous structures in rock subtypes B-3d and B-4a are essentially the same. The light-colored band in Figure 2 is the result of parting during preparation of the thin section. See Table 10 for list of components in structures. Sample 1113 from about 10 feet above base of the middle member of Stonehenge Limestone at Glenside, section No. 1.

Figure 3.—Naturally weathered surface of subtype B-3d perpendicular to stratification.

Figure 4.—Acid etched surfaces of rock of subtype B-4a, siliceous-laminated, roughly fracturing cryptogranular limestone. Dark siliceous lamina in Figure 4a resembles overturned small-scale fold. Laminae are similar in make-up to those of subtype B-3d (see Table 11) but are of more regular morphology and are separated by bands with thin, silty and dolomitic laminae. The thin, silty laminae are commonly cross-bedded. Figure 4a of sample 1114 from 16-½ feet above base of the lower member of Stonehenge Limestone at Glenside, section No. 1. Figure 4b of sample 16211 from 646 feet above base of the Epler Formation at Epler School, section No. 4.

Figures 5, 6.—Thin section views of the bands between the siliceous laminae in rock type B-4a showing clastic appearance of the limestone. Some of the calcite silt and arenite particles appear to be pelmatozoan plates and larger pelmatozoan fragments are common. Figure 5 reveals a fragmentation of the bands into irregularly shaped fragments. Dark laminae in Figure 5 appear styolitic in part. Sample 16211 from 646 feet above the base of Epler Formation at Epler School, section No. 4.

PLATE 17

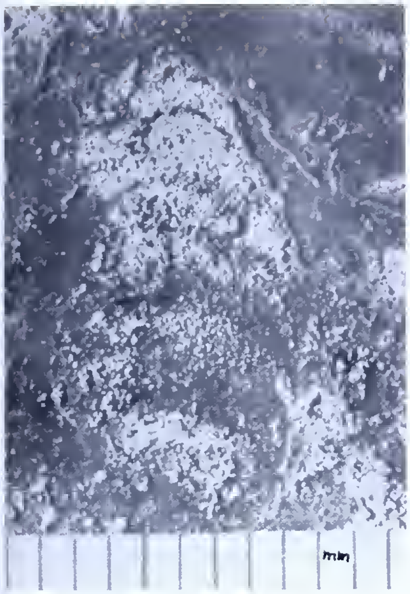


Figure 1

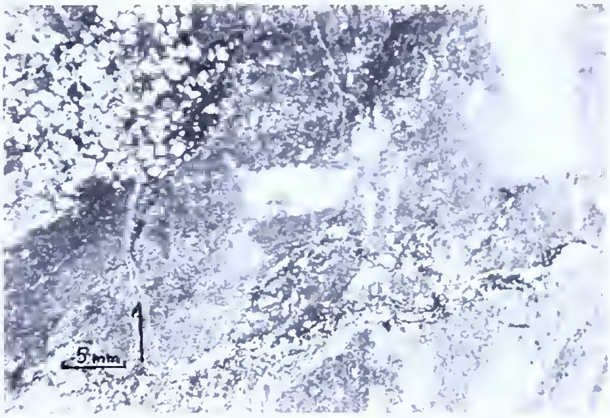


Figure 2

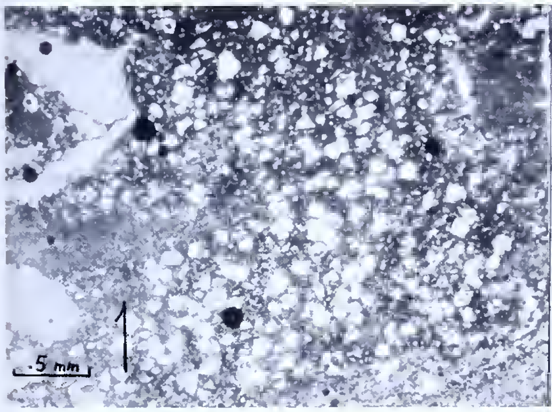


Figure 3

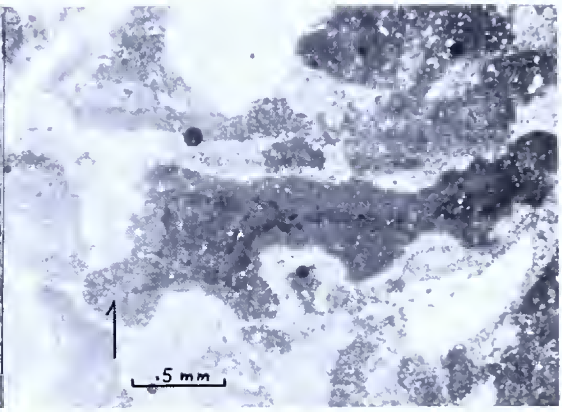


Figure 4

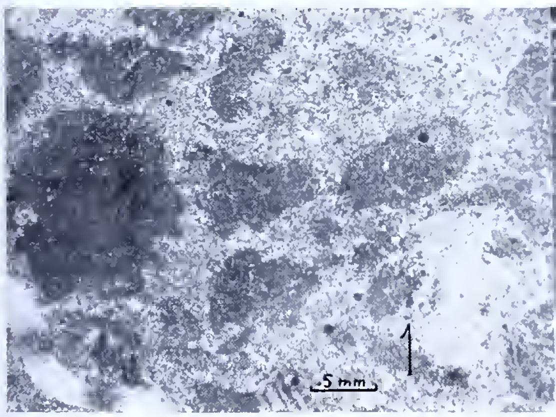


Figure 5

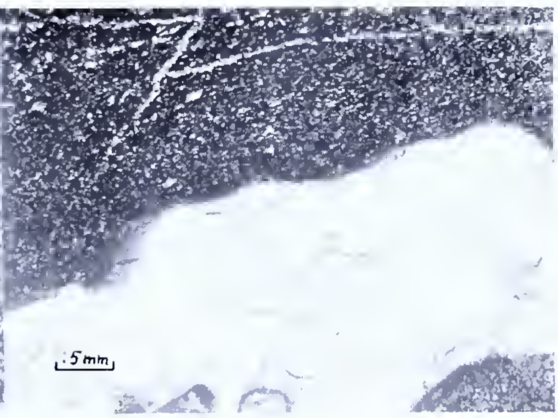


Figure 6

PLATE 18

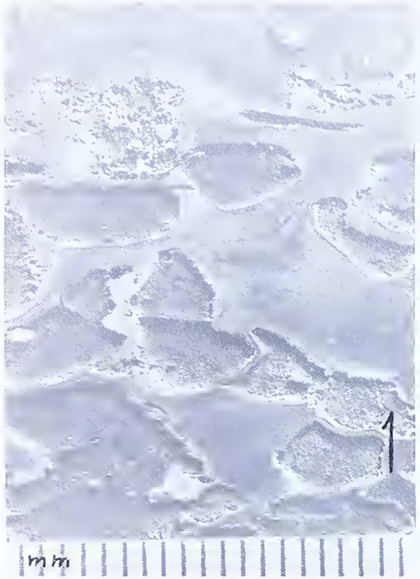


Figure 1

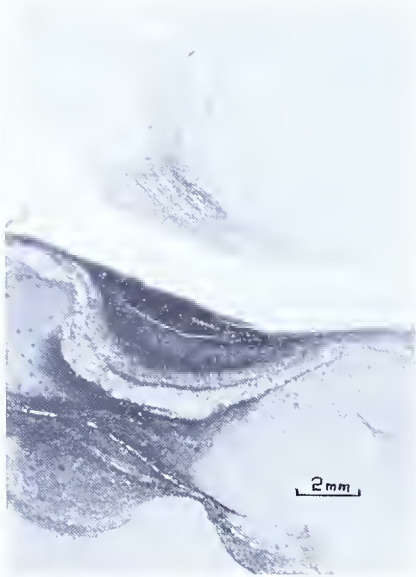


Figure 2

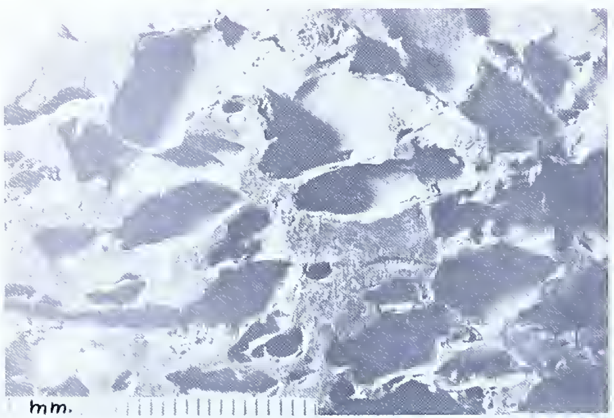


Figure 3

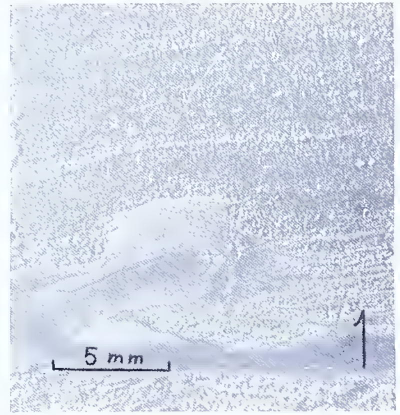
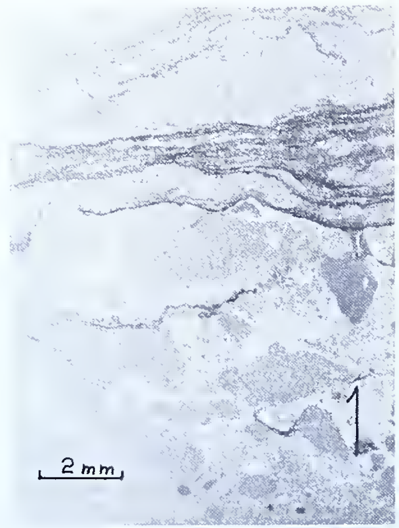


Figure 4a

Figure 4b

Figure 5



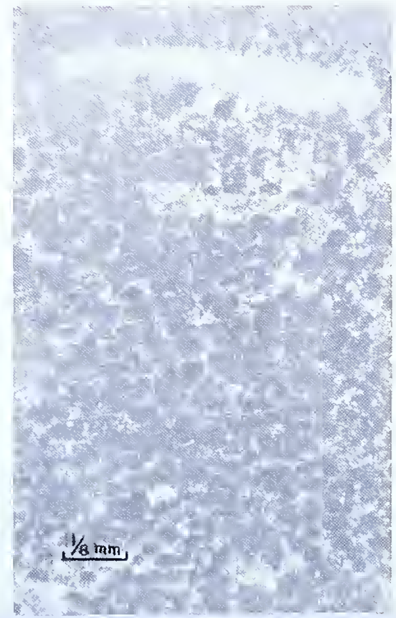


Figure 6

PLATE 19

Figures 1, 2.—This section view of rock of subtype B-5b showing irregular, elongate to platy fragments composed of dolomite and submicrocrystalline calcite that are characteristic of this subtype as it occurs in "channels" of the upper member of the Stonehenge. Here, the fragments are aligned and oriented subparallel to base of channel-like structure. The clustered and scattered dolomite anhedra and subhedra are limonitic stained and appear confined to the fragments and grains. Pelmatozoan plates, with optically continuous sparry overgrowths in places, are intermixed with the fragments. The clastic grains are cemented by sparry calcite or surrounded by microcrystalline calcite matrix. Pebbly calcarenite as found in the "channels" of the Stonehenge is unlike that found elsewhere in the studied samples in terms of fragment morphology and internal make-up (see Plate 20). Sample 1125 from the upper member of Stonehenge Limestone at Glenside, section No. 1.

Figures 3, 4.—Etched and thin section views of rock of subtype B-5b in the Epler Formation. The rock is composed of fossil fillings, shells, and pelmatozoan plates cemented by sparry calcite. A number of fragments have distinct shell borders and several complete gastropods are visible in Figure 3. Pelmatozoan plates commonly have optically continuous overgrowths. Sparry calcite cement is made up of recrystallized shells, overgrowths, recrystallized matrix (?), and perhaps some primary crystals. Sample 16113 from 305-½ feet above the base of the Epler Formation at Epler School, section No. 4.

Figure 5.—Etched section view of dolomitic pebbly calcarenite (B-5b) composed in large part of fragments of fossil fillings. Development of dolomite in the filling is evident. Sample 16189 from 564 feet above the base of the Epler Formation at Epler School, section No. 4.

Figure 6.—Acid etched surface of rock of subtype B-5b. Patchy development of dolomite surrounds clastic grains which show no preferred orientation with respect to bedding. Dolomite is apparently confined largely to matrix calcite. Sparry cement is visible as darker material surrounding grains. Sample 16122 from 329 feet above the base of the Epler Formation at Epler School, section No. 4.

PLATE 20

Figure 1.—Etched section of rock of subtype B-6b from the middle member of the Stonehenge showing intermixed platy and elongate fragments, calcite silt, and calcite sand cemented by sparry calcite and dolomite. The fragments are angular to round and contain thin silty and silty (quartz) -dolomitic laminae identical to those rock subtype B-4a which is interbedded with subtype B-6b. Distribution of interfragment dolomite is patchy. Sample No. 1213 from 55-½ feet above the middle member of Stonehenge Limestone at Wyomissing, section No. 11.

Figure 2.—Etched surface of rock of subtype B-6b showing distribution of dolomite immediately beneath fragments, a feature common in rock of this subtype. Fragments are composed of silty-laminated limestone, similar to rock subtype B-4a, and of fragmental limestone similar to that found in lenses in rock of subtype B-3d. Diastemic surface occurs in the rock near the base of the photograph. Sample 129 from beds between 11-½ and 45-½ feet above the lower member of Stonehenge Limestone at Wyomissing, section No. 11.

Figures 3 - 6.—Etched and thin section views of rock of subtype B-6a and B-6b showing elongate and platy fragments and calcite sand and silt grains in a sparry calcite cement. The larger fragments, composed of calcisiltite, silty fine carcarenite, and submicrocrystalline calcite, are oriented subparallel to bedding. As in the Stonehenge, many of the fragments are of rock of subtype B-4a with which rock of type B-6 is interbedded. Some of the fragments possibly have recrystallized shell borders. Dolomite is visible as scattered and clustered crystals in Figures 4 and 6. Sample 16187 in Figures 3 and 4 from about 559 feet and Sample 16215 in Figures 5 and 6 from 684-½ feet above the base of Epler Formation at Epler School, section No. 4.

PLATE 19

Figure 1

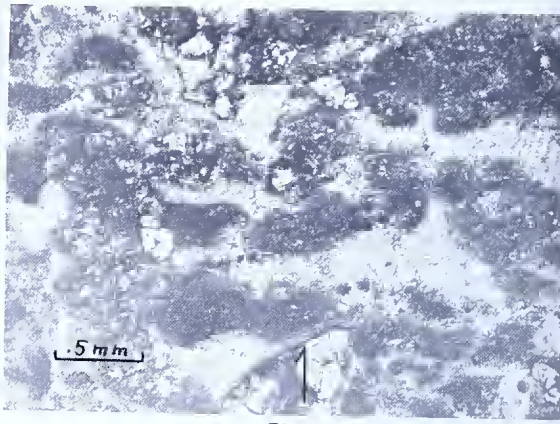


Figure 2

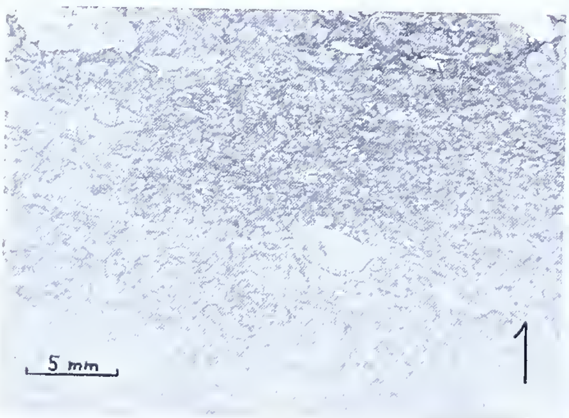


Figure 3

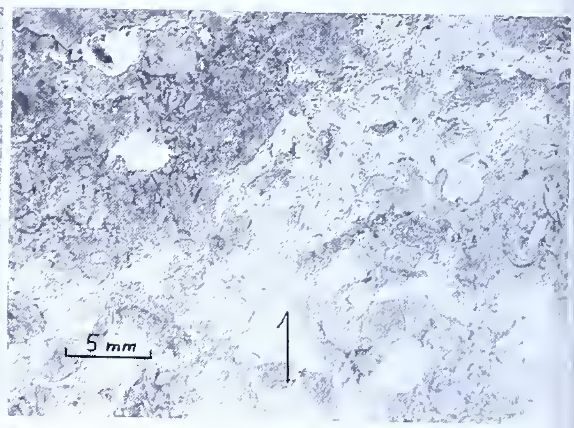


Figure 4

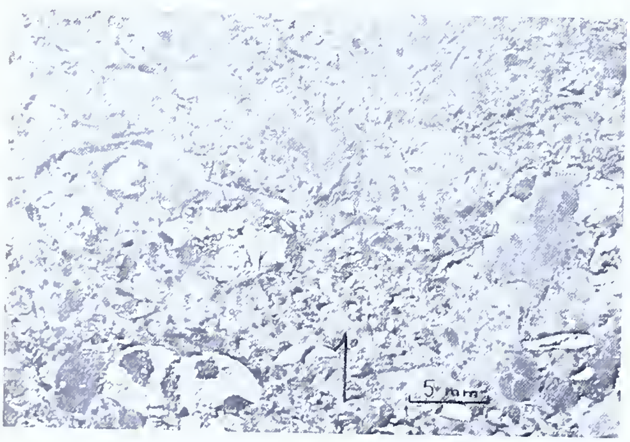


Figure 5

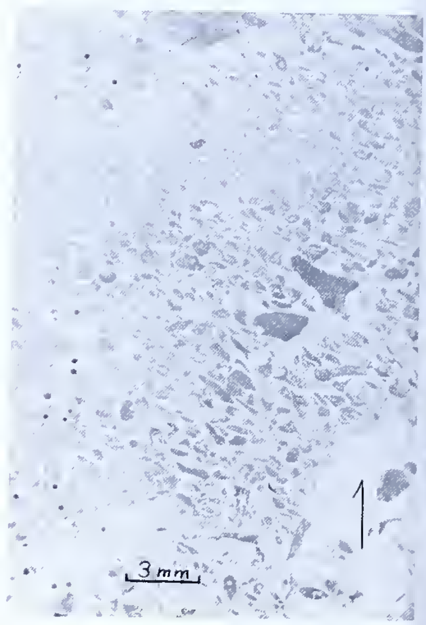


Figure 6

PLATE 20

Figure 1

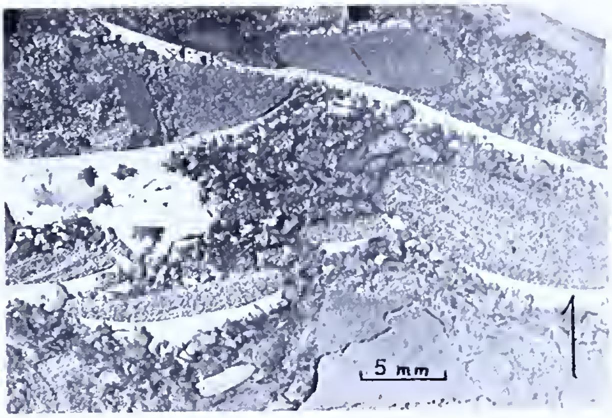


Figure 2

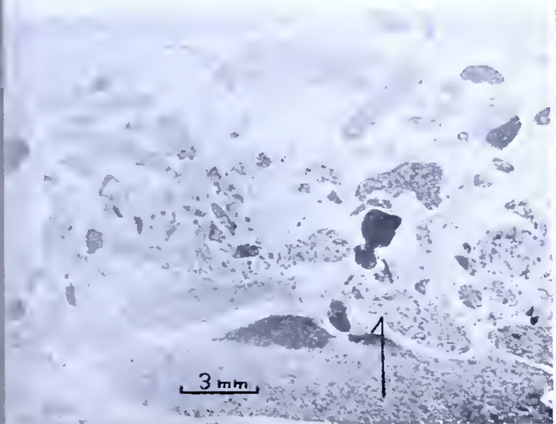


Figure 3

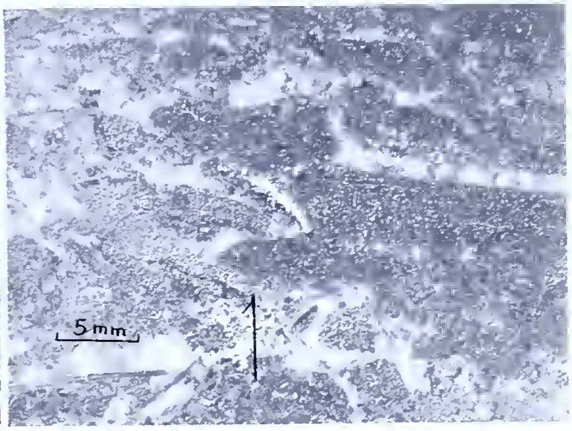


Figure 4

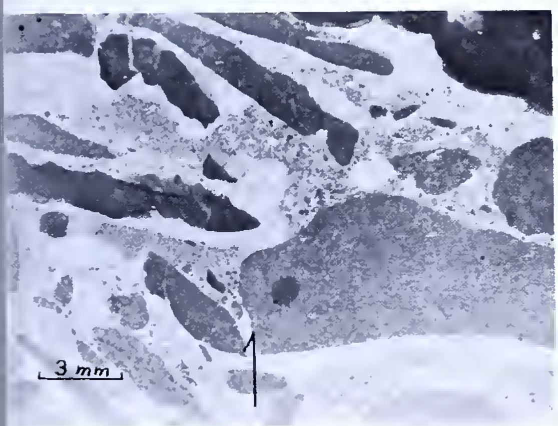


Figure 5

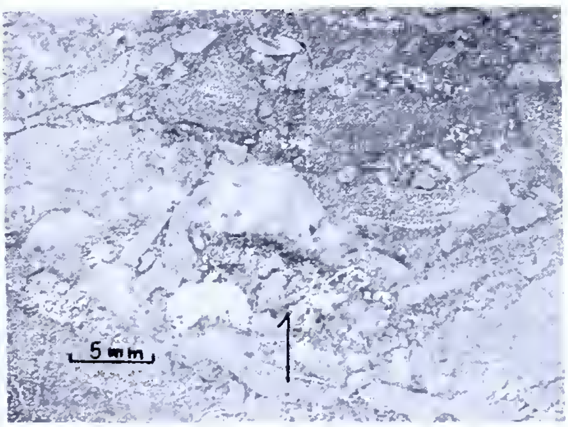


Figure 6

PLATE 21

Figures 1, 2.—Etched section views of rock of subtype B-3b. Lobate to subreticulate, very finely megacrystalline, dolomitic mottles in smoothly fracturing cryptogranular limestone. Fragmented lenses composed in part of fossil fillings, as suggested by the fragments, shaped like the chambers of gastropods. Boundaries of dolomite structures vary from sharp to gradational with "floating" dolomite rhombs in the transition zone. Morphology of dolomite structures may be the result of: (1) mixing of calcite and dolomite sediment, or (2) selective dolomitization. The irregular, anastomosing morphology and the sharp interfaces between the calcite and dolomite structures suggest a slumping and mixing dolomitized sediment and lime mud with subsequent dolomization around the edges of the calcite parts in some places. Figure 1 of sample No. 1681, Figure 2 of sample No. 1684 from 191 feet and 192 feet respectively above the base of the Epler Formation at Epler School, section No. 4.

Figure 3.—Etched section of rock of subtype B-5b showing association of dolomite with silty-argillaceous and dolomitic laminae. There appears to be a tendency for a better development of dolomite immediately beneath the laminae in this sample. Sample 1699 from 255-½ feet above the base of the Epler Formation at Epler School, section No. 4.

Figures 4, 5.—Acid etched surfaces of rock of subtype B-4b. Randomly disposed lobes and lenses of very finely megacrystalline dolomite in roughly fracturing cryptogranular limestone. Boundaries of dolomite mottles sharp to gradational. This type of mottling is commonly associated with dolomite "fucoids" on bedding surfaces. Dolomite in Figure 5 has a sub-banded concentration and contains numerous ring-like dolomite clusters that are apparently cross sections of the tubular and cylindrical structures observed to be arranged along the bedding surface. Figure 4 of sample No. 16167, Figure 5 of the sample No. 16139 from 485-½ feet and 396 feet above the base of the Epler Formation at Epler School, section No. 4.

Figure 6.—Acid etched surface of rock of subtype B-6b, dolomitic sandy calcirudite. Elongate and platy, sub-rounded fragments of microcrystalline and submicrocrystalline calcite are intermixed with calcite sand and are arranged subparallel to bedding. Sample No. 1680 from 190-½ feet above the base of the Epler Formation at Epler School, section No. 4.

PLATE 21

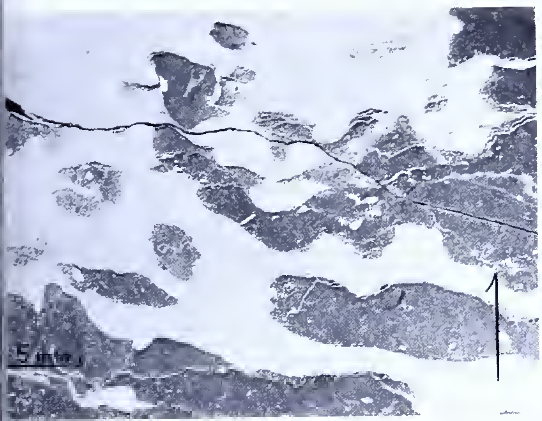


Figure 1

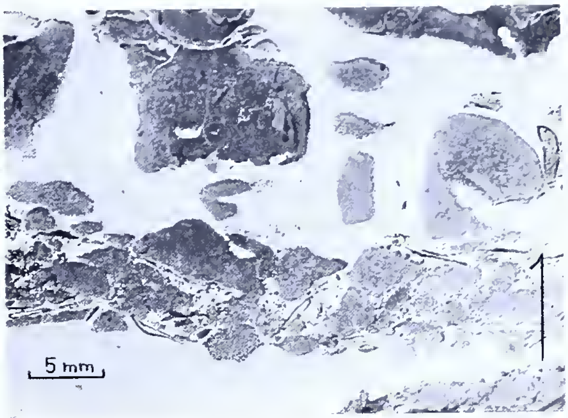


Figure 2

Figure 3

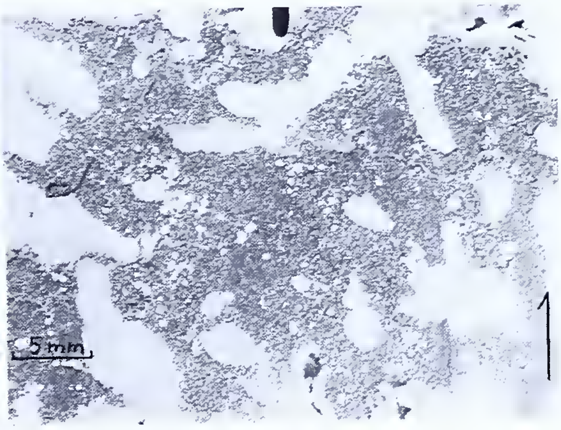


Figure 4

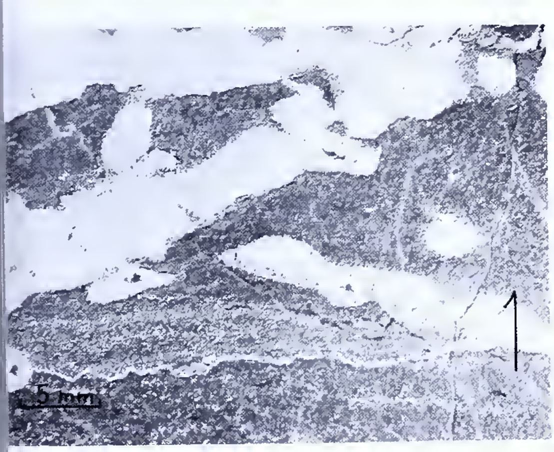


Figure 5

Figure 6

APPENDIX II

DETAILED MEASURED SECTIONS

Annville limestone. Approximate outcrop.

Figure 26. Location of sections 14-24, Lebanon and Dauphin Counties.

SECTION NUMBER 1

Glenside, Pennsylvania

Date described: August, 1955
Date sampled: August, 1955

Location and structure of section

Section No. 1 is along northwest bank of Schuylkill River in borough of Glenside, suburb of northwest Reading, Berks County, Pennsylvania. Exposures are in west central part of Reading quadrangle approximately 0.95 miles north of 40° 20' latitude and 1.58 miles west of 75° 55' longitude (Fig. 3).

Uppermost exposed beds disturbed by folds uncertain in detail owing to obscurity of bedding and poor exposure. Three readings indicate remaining beds strike N75°E and dip 30°SE. Dip (ac) joint surfaces show trace of closely spaced cleavage plunging to southeast at angles steeper than dip of bedding, indicating upright bedding.

Section description	Thickness (feet) unit	total
Lower Ordovican Series		
Beekmantown Group		
Rickenbach Dolomite		
Dolomite, medium gray (N5), medium megacrystalline (B-2), weathering medium light gray (N6); dolomite interbedded with medium-dark-gray (N4), dolomitic-mottled cryptogranular limestone (B-3b), weathering light gray (N7). Samples no. 1126 from dolomite, no. 1127 from limestone. Estimated thickness.	25	25
Exposed thickness of lower Rickenbach Dolomite		25
Stonehenge Limestone		
Upper member		
Limestone. Predominant lithology (B-3c) is medium-gray (N5) to medium-light-gray (N6) smoothly fracturing cryptogranular limestone with scattered calcarenite and 1/4-mm. to 1/2-mm. scattered and clustered crystals of sparry calcite; limestone weathering light		

	Thickness (feet) unit	total
gray (N7) with very irregular, yellowish-gray to black-weathering (5Y8/1-N5) laminae; numerous mound-like, structureless masses, resemble small reefs; scattered lobes and lenses of yellowish-gray-weathering dolomite; subordinate lithology (B-5b) is bioclastic pebble calcarenite with discontinuous, styolitic, silty-argillaceous laminae and with scattered patches of intergranular dolomite. Association of the two rock lithologies is complex; calcarenite in large irregular, elongate, channel- and dike-like bodies cutting irregular stratification of the cryptogranular lithology. Scattered and clustered orthid brachiopod valves resembling Finkelnburgia sp. and Nanorthis? sp. and fragments of trilobites; channel fillings in some places composed largely of closely packed brachiopod valves. Measurement of unit complicated by obscure folds. Samples no. 1122 from cryptogranular body; no. 1125 from calcarenite.	60	60
Thickness of upper member		60
Middle member		
Limestone (B-4c), medium gray (N5), roughly fracturing cryptogranular, weathering medium light gray (N6), with 1/2-inch to 4-inch bands of dolomitic laminae weathering yellowish gray (5Y8/1) to reddish brown (10R3/4) and intercalated with thinner irregular bands of parallel- and cross-bedded, silty laminae and 1-inch to 5-inch bands and irregular lenses of bioclastic, pebble calcarenite (B-5b) with yellowish-gray (5Y8/1)-weathering intergranular dolomite. Samples no. 1123 and no. 1124. Thickness measurement complicated by folding.	8	51
Limestone, medium gray (N5), parting into poorly developed 6-inch layers. Predominant lithology (B-4a) is roughly fracturing cryptogranular with parallel- and cross-bedded silty		

	Thickness (feet) unit	total
laminae in 1-inch to 1-foot layers separated by 1/8-inch to 1/2-inch, anastomosing dolomitic and siliceous laminae, weathering yellowish gray (5Y8/1) to shiny black (N1). Subordinate lithology (B-6b) is calcirudite in numerous 2-inch to 4-inch beds consisting of 1/8-inch- to 4-inch-long, elongate to platy, subrounded, silty-laminated fragments in matrix of dolomitic calcarenite. Rock bodies composed of the two lithologies are regularly interbedded becoming generally thinner and more numerous in the lower 8 feet. Discontinuous partings develop parallel to rock cleavage along which movement has distorted sedimentary structures. No samples.	16	43
Limestone, medium gray (N5), parting into poorly-developed 6-inch layers. Unit consists of two cycles each composed of three lithologies; typical cycle composed of 6 inches of calcirudite (B-6b) at base overlain by 6 inches of cryptogranular limestone (B-3d) with fine calcarenite lenses, and irregular black-weathering, subreticulated siliceous mottling; this lithology grades upward and is intermixed with 6 inches of silty-laminated cryptogranular limestone (B-4a) in 1-inch bands separated by 1/4-inch irregular, black-weathering (N1), anastomosing siliceous laminae; the uppermost rock bodies in each cycle separated commonly by a sharp, undulating surface from overlying conglomerate layer. Samples no. 1118 at 6 inches; no. 1119 at 1 foot; no. 1120 at 3 feet above base of unit.	3-1/2	27
Limestone, medium gray (N5), parting into poorly developed 6-inch layers. Predominant lithology (B-4a) is roughly fracturing cryptogranular with irregular, lensing bands of parallel- and cross-bedded silty laminae separated by irregular 1/8-inch to 1/2-inch anastomosing, siliceous laminae. Subordinate lithology is calcirudite (B-6b) in 1-foot beds at base and top and 3-inch to 6-inch layers		

	Thickness (feet) unit	total
between. Flowage has produced distortion of sedimentary structures and much of the anastomosing appears to have taken place along planes of flowage. Samples no. 1116 at 0 feet; no. 1117 at 3 feet above base.	6-1/2	23-1/2
Limestone, medium gray (N5), parting into poorly-developed 6-inch layers. Unit consists of rock body cycles composed of three lithologies; typical cycle contains calcirudite (B-6b) in 6-inch beds, overlain by 1-foot to 2-foot layers of cryptogranular limestone (B-3d) which grades up into and is intermixed with 1-foot to 2-foot beds of silty-laminated cryptogranular limestone (B-4a); calcirudite bodies separated below by sharp, welded, undulating surfaces and overlie either of the other types but usually silty-laminated limestone. Lowermost few feet of unit contains cylindrical, branching, yellowish-gray-weathering dolomite structures resembling fucoids; six dolomitized gastropods resembling <u>Ophileta</u>? sp. on bedding surface. Samples no. 1110 at 2 feet; no. 1111 at 3 feet; no. 1112 at 3-1/2 feet; no's. 1113, 1114, 1115 from upper 7 feet.	10-1/2	17
Limestone, medium gray, (N5), cryptogranular (B-4c), weathering medium light gray (N6), parting into irregular 2-foot layers; irregular, wavy, black-weathering (N1), laminated 2-inch to 4-inch bands along which discontinuous partings develop; bands become yellowish-gray-weathering laminae in upper 4 feet and grade downward into 6 inches of shaly, laminated, deeply weathered dolomite with 1-inch bands of limestone containing yellowish-gray-weathering, crinkly laminae. Samples no. 117 at 0 feet; no. 118 at 6 feet; no. 119 at 6 inches above base.	6-1/2	6-1/2
Thickness of middle member		51

	Thickness (feet) unit	total
Lower member		
Dolomite, medium gray (N5), very finely megacrystalline (B-1b) parting into 6-inch to 1-foot layers; regular parallel laminae. Sample no. 116 at 4 feet.	5	28
Limestone, medium gray (N5), cryptogranular (B-4c), weathering light gray (N7), parting into 4-foot layers; micro-folded laminae and streaks weathering yellowish gray (5Y8/1) and bisected by well-defined rock cleavage traces; 2 feet of calcirudite (B-6b) 1 foot below top. Samples no. 114 at 1 foot; no. 115 at 9 feet above base of unit.	10	23
Dolomite, very slowly effervescent, medium gray (N5), very finely to finely megacrystalline (B-1b), weathering yellowish-gray (5Y8/1); regular parallel laminae; indistinct mud cracks on weathered bedding surface. Samples no. 112 at 2 feet; no. 113 at 4 feet above base of unit.	7	13
Limestone, medium gray (N5), cryptogranular (B-4c), weathering light gray (N7) with lensing 1/8-inch to 3/4-inch, finely megacrystalline laminae weathering yellowish gray (5Y8/1) and comprising about 40 percent of the surface area. Sample no. 111 at 5 feet above base of unit.	6	6
Exposed thickness of lower member		28
Exposed thickness of Stonehenge Limestone		139

Distance to Cambrian beds concealed by river at this point.

SECTION NUMBER 2

Rickenbach, Pennsylvania (No. 1)

Date described: August, 1955
Date sampled: August, 1955

Location and structure of section

Type section of lower member of the Rickenbach Dolomite is exposed in cut along west side of Reading Company's railroad tracks 1000 feet south of crossing at Rickenbach, Berks County, Pennsylvania. Exposures are in the northwest part of Reading quadrangle approximately 0.40 miles north of 40° 25' latitude and 2.10 miles west of 75° 55' longitude (Fig. 3).

From three readings, beds strike N27°E and dip 77°NW. Extensive joint surfaces not apparent; measurable small joints largely confined to beds of finer texture. Plotted poles of 17 joints form NE-SW girdle on Schmidt net with dips varying between the vertical and 10°. Rock cleavage not visible.

Traverse made with 100-foot tape along base of outcrop and parallel to railroad tracks trending S27°E. Measurement begins at top of uppermost exposure on southwest side of tracks southeast of railroad crossing at Rickenbach and continues stratigraphically downward to uppermost Cambrian limestone and dolomite. Traverse distance to base of each unit is given in parentheses at end of each unit description. Traverse from 0 feet to 39 feet, bedding N35°E, 77°NW; from 39 feet to 320-1/2 feet, bedding N20°E, 77°NW; from 320-1/2 feet to 1325-1/2 feet, bedding N32°E, 62°NW. Samples located at stratigraphic distance above base of each description unit.

Section description	Thickness (feet) unit	total
Lower Ordovician Series		
Beekmantown Group		
Rickenbach Dolomite		
Upper member		
Dolomite, light gray (N7), finely megacrystalline (B-1a), weathering light yellowish-gray (5Y8/1), parting into 6-inch layers. Sample no. 151, 1 foot above base of unit. (8-1/2 feet).	7-1/2	37-1/2
Dolomite, medium light gray (N6), finely		

	Thickness (feet) unit	total
megacrystalline (B-1a), weathering medium light gray (N6) with moderate-brown (5YR4/4)-stringers and nodules of dark-gray (N3) chert. (9-1/2 feet).	1	30
Dolomite, medium gray (N5), finely megacrystalline (B-1b), weathering light gray (N7); several zones of indistinct, regular, parallel laminae; moderate-brown (5YR4/4)-stained, 1-inch to 6-inch, dark-gray (N3) chert nodules and stringers in middle; some of chert is fragmented in channel-like pockets cutting the laminae and with laminae draped over fragments in places. Sample no. 153, 1 foot above base of unit. (18 feet).	7-1/2	29
Dolomite, medium light gray (N6), very finely megacrystalline (B-1a), weathering very light gray (N8) to white (N9); 1/2-inch stringers of dark-gray (N3) chert weathering with pitted surface. Sample no. 154 at base. (20 feet).	1-1/2	21-1/2
Chert layer (B-7), dark gray (N3); rusty-brown staining. (21 feet).	1	20
Concealed. (23 feet).	1-1/2	19
Dolomite, medium gray (N5) to medium light gray (N6) in splotchy to streaked distribution and with several dark gray streaks in the upper portion, finely megacrystalline (B-1e), weathering medium light gray, parting into 1-1/2-foot layers. Samples no. 155 at 5 feet; no. 156 at 3 feet above base of unit. (30 feet).	6	17-1/2
Chert layer (B-7), medium gray (N4) to dark gray (N3), stained rusty-brown with pitted, dolomoldic, weathered surface. Sample no. 157. (31 feet).	1	11-1/2
Dolomite, light gray (N7), finely megacrys-		

	Thickness (feet) unit	total
talline (B-1a), weathering very light gray (N8) with irregular stringers and lenses of dark-gray (N3) chert. No sample. (33-1/2 feet).	2	10-1/2
Concealed. (36 feet).	2	8-1/2
Dolomite, light gray (N7), finely megacrystalline (B-1a), weathering medium light gray (N6); lower portion in contact with chert is finely to medium megacrystalline. Sample no. 158 at base. (38-1/2 feet).	2	6-1/2
Chert layer (B-7), medium dark gray (N4), weathering light brown (5YR5/6) with dolomoldic pitted surface. (39 feet).	1/2	4-1/2
Dolomite, light gray (N7), finely megacrystalline (B-1c), weathering very light gray (N8); 2-mm. to 5-mm. medium-light-gray (N6) laminae alternating with thinner, calcareous, laminae which weather inward; several scattered white chert rosettes. Sample no. 159 at base of unit. (42 feet).	2	4
Concealed. (45 feet).	2	2
Exposed thickness of upper member		37-1/2
Lower member		
Dolomite, medium light gray (N6) to medium dark gray (N4), finely to medium megacrystalline (B-2c to B-1f); darker areas weather into relief as thin, anastomosing, siliceous stringers, lobes and lenses. Sample no. 1510. (48-1/2 feet).	2-1/2	225-1/2
Dolomite, medium light gray (N6), finely megacrystalline (B-1b), weathering very light gray (N7), laminated, parting into 1-1/2 foot layers; dark-gray chert nodules at base of unit. Sample no. 1511 at base. (52 feet).	2-1/2	223

	Thickness (feet) unit	total
Dolomite, medium gray (N5), medium to coarsely megacrystalline (B-2), weathering light gray (N7); irregular laminae and bands becoming regular laminae at base. No sample. (53 feet).	1	220-1/2
Dolomite, medium gray (N5), finely megacrystalline (B-1b), weathering light gray (N7), laminated. (55 feet).	1-1/2	219-1/2
Dolomite, medium gray (N5) to medium light gray (N6), finely megacrystalline (B-1f), parting into 3-inch layers; raised light-brown (5YR5/6)-weathering, irregular, siliceous stringers, lobes and lenses on weathered surface. No sample. (55-1/2 feet).	1/2	218
Dolomite, light gray (N7), finely megacrystalline (B-1a) weathering light gray; lower 4 inches regularly laminated (B-1b). No sample. (56-1/2 feet).	1	217-1/2
Dolomite, medium gray (N5) to medium light gray (N6), finely megacrystalline (B-1a), weathering light gray (N7), parting into 1-foot layers. Sample no. 1512 at base of unit. (59 feet).	2	216-1/2
Dolomite, medium gray (N5), finely megacrystalline (B-1a), weathering yellowish gray (5Y8/1), parting into 6-inch layers. Sample no. 1513. (61-1/2 feet)	2	214-1/2
Dolomite, light gray (N7), finely megacrystalline (B-1b); regular wavy laminae; scattered rosettes of white chert. Sample no. 1514 at 2 feet above base. (68 feet).	4-1/2	212-1/2
Dolomite, medium gray (N5) to medium light gray (N6) in splotchy distribution, finely megacrystalline (B-1e). Sample no. 1515 at base. (69 feet).	1	208

	Thickness (feet) unit	total
Concealed.	4-1/2	207
Dolomite, medium gray (N5), medium megacrystalline (B-2c); thin light-brown (5YR5/6)-weathering, siliceous laminae. Sample no. 1516 at 1 foot above base. (79 feet).	2-1/2	202-1/2
Concealed. (104 feet).	18	200-1/2
Dolomite, medium dark gray (N4), medium to coarsely megacrystalline (B-2), weathering light gray (N7); disseminated microfractures (B-2e) filled with white dolomite; several lenses of apparent breccia (B-2d) consisting of angular medium-megacrystalline dolomite fragments cemented by milky-white dolomite crystals; indistinct laminae (B-2b) at base. Sample no. 1517 at 6-1/2 feet above base of unit. (114 feet).	7	182
Concealed (160-1/2 feet).	31-1/2	175
Dolomite, medium dark gray (N4), medium to coarsely megacrystalline (B-2); 1-foot layer at top consisting of 1/2-mm. to 3-mm., equant to elongate, angular to subrounded, medium-dark-gray dolomite grains in a medium-light-gray (N6), finely megacrystalline matrix (B-2d). Samples no. 1518 at top, no. 1519 at base. (168-1/2 feet).	5-1/2	143-1/2
Dolomite, medium light gray (N6), finely megacrystalline (B-1a), weathering light gray (N7); layer of angular dolomite fragments at base. No sample. (170-1/2 feet).	1-1/2	138
Dolomite; alternating medium-dark-gray (N4) and medium-light-gray (N6) 1/2-inch laminae; finely megacrystalline (B-1b), weathering medium light gray. Sample no. 1520. (171-1/2 feet).	1/2	136-1/2
Exposures; dolomite, medium light gray (N6)		

	Thickness (feet) unit	total
medium megacrystalline (B-2). No sample. (180-1/2 feet).	6-1/2	136
Dolomite, medium gray (N5) to medium dark gray (N4) in splotchy distribution, medium megacrystalline (B-2b), weathering medium light gray (N6); irregular wavy laminae seperate unit into 1-inch bands. Samples no. 1521 at top; no. 1522 at 1 foot above base. (185-1/2 feet).	3-1/2	129-1/2
Dolomite, medium light gray (N6), finely megacrystalline (B-1b); regular parallel laminae. No sample. (186-1/2 feet).	1/2	126
Concealed. (188 feet).	1	125-1/2
Dolomite, medium gray (N5), medium megacrystalline (B-2b), parting into 1-foot layers; 1-mm. to 5-mm. zones of thin laminae; laminated zones weather in relief and are separated by 3-mm. to 1-cm. zones of light-gray (N7)-weathering, indistinctly laminated dolomite; stringers and nodules of white chert common throughout unit. Sample no. 1523 at 1-1/2 feet above base of unit. (191-1/2 feet).	2-1/2	124-1/2
Dolomite, medium light gray (N6), medium megacrystalline (B-2c); irregular, wavy, siliceous laminae weather into relief; lower 6 inches appears to consist of indistinct dolomite breccia (B-2d). Sample no. 1524 at 2 feet. (197-1/2 feet).	4	122
Dolomite, medium gray (N5), finely to medium megacrystalline (B-2e), weathering light gray (N7); disseminated, irregular, microfractures 1-mm. to 5-mm. long and filled with white dolomite; stringers and nodules of black chert concentrated along bedding. Sample no. 1525. (199 feet).	1	118
Dolomite, medium megacrystalline (B-2b),		

	Thickness (feet) unit	total
weathering light gray (N7); alternating 1-mm. to 2-mm. medium-light-gray (N6) and medium-dark-gray (N4) laminae; disseminated, irregular, micro-fractures filled with white dolomite (B-2e). Sample no. 1526. (201-1/2 feet).	1-1/2	117
Concealed. (213-1/2 feet).	8-1/2	115-1/2
Dolomite, medium gray (N5), medium megacrystalline (B-2e) weathering light gray (N7); disseminated micro- fractures filled with white dolomite; scattered, irregular lenses of white chert. Sample no. 1527, 2 feet above base. (218 feet).	3-1/2	107
Concealed. (221-1/2 feet).	2-1/2	103-1/2
Dolomite, medium gray (N5), medium megacrystalline (B-2e), weathering very light gray, (N8) parting into 1-1/2-foot layers; disseminated micro-fractures as in units above. Sample no. 1528 at 1 foot above base of unit. (228-1/2 feet).	5	101
Concealed. (240-1/2 feet).	2	96
Dolomite, medium gray (N5) to medium light gray (N6), finely mègacrystalline (B-2e), deeply-weathered light gray with a gritty, crumbly surface; disseminated micro-fractures as in units above. Sample no. 1529 at 2 feet above base. (245-1/2 feet).	3-1/2	94
Concealed. (249 feet).	2-1/2	90-1/2
Dolomite, medium light gray (N6), finely megacrystalline (B-1b), weathering light gray (N7); regular parallel laminae. Sample no. 1530 at 1 foot above base. (251-1/2 feet).	2	88
Dolomite, medium gray (N5) to medium dark gray (N4), medium to coarsely megacrystalline		

	Thickness (feet) unit	total
(B-2e), weathering medium light gray (N6); disseminated micro-fractures filled with white dolomite as in units above. Sample no. 1531 at 2 feet. (258 feet).	4-1/2	86
Concealed. (263-1/2 feet).	4	81-1/2
Dolomite, medium gray (N5), medium megacrystalline (B-2), weathering medium light gray (N6); nodules, clusters and stringers of white dolomite; laminae in lower 4 inches. Sample no. 1532 at 2 feet above base of unit. (268 feet).	3	77-1/2
Concealed. (304 feet).	25-1/2	74-1/2
Exposures, dolomite, medium gray (N5), finely to medium megacrystalline (B-2e); disseminated micro-fractures filled with white dolomite. Sample no. 1533 from upper beds. (338 feet).	24	49
Dolomite, medium light gray (N6), finely megacrystalline (B-1b), laminated to banded; zone in middle of unit consists of 2-inch to 3-inch, subangular, dolomite fragments and smaller angular fragments of dark-gray chert (B-1i); 1-foot zone 6 inches above base consists of regular parallel laminae disrupted by erosional pocket containing angular chert fragments. Samples no. 1534 at top; no. 1535 at 3 feet above base. (350 feet).	8-1/2	25
Concealed. (361 feet).	8	16-1/2
Dolomite, medium dark gray (N4), finely megacrystalline (B-1b), weathering medium light gray (N6); several zones of black-weathering laminae and streaks; lowermost 1 foot contains 1/2-foot-long, angular blocks of laminated dolomite (B-1i). Sample no. 1536 at 8 feet above base of unit. (373 feet).	8-1/2	8-1/2
Exposed thickness of Rickenbach formation		225-1/2

	Thickness (fee[t]) unit	tot[al]
Concealed. (653 feet).	200-250	
Concealed; exposures (5 percent) at north end of traverse consist of very finely megacrystalline, laminated dolomite, resembling that of the lower member, Stonehenge formation. (1378 feet).	500-550	
Cambrian system		
Conococheague formation		
Thick section of interbedded limestones and dolomites, numerous zones of stromatolites, cryptozoan type, oolite, oolitic chert, and quartz sand. Layer of cross-bedding at base and upright stromatolites, cryptozoan type near top indicate tops to the north.	not measure[d]	

SECTION NUMBER 3

Epler School, Pennsylvania (No. 1) Date described: July, 1955
Date sampled: July-August, 1955

Location and structure of section

Type section of upper member of the Rickenbach Dolomite is along southwest bank of Schuylkill River one-half mile east by northeast of Epler School, Berks County, Pennsylvania. Exposures are in west central part of Reading quadrangle approximately 1.90 miles south of 40° 25' latitude and 1.70 miles east of 76° 00' longitude (Fig. 3). Section begins where natural-gas pipe passes under river and continues northwestward and stratigraphically upward to base of lowermost limestone in exposures. Section is continuous upward with section no. 4, type section of the Epler Formation.

Section is on normal northwest dipping limb of anticline. From 11 readings beds strike N20°E and dip 60°NW. Cleavage and upright stromatolites, cryptozoon type, in overlying limestones indicate upright beds. Cleavage and joint information given in description of section no. 4. Thickness values not accompanied by traverse data were obtained with an 8-foot tape held perpendicular to bedding.

Section description	Thickness (feet) unit	total
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Exposures; chert, 1-foot to 2-foot layers, dark gray (N3); abundant dolomite float.	not measured	
Concealed; traverse N33°W, 150 feet; bedding N15°E, 68°NW; parts of concealed strata exposed and described in sections 5, 7 and 9.	100	100
Measured thickness of Ontelaunee Formation		100
Epler Formation		
Type section of Epler Formation (section 4)	798	798
Measured thickness of Epler Formation		798

	Thickness (feet) unit	total
Rickenbach Dolomite Upper member		
Concealed. Traverse about N72°W perpendicular to general strike of bedding, 51 feet; bedding dip 61°NW.	45	23[illegible]
Dolomite, medium gray (N5), very finely megacrystalline (B-1b) parting into 2-foot layers; regular parallel laminae. No sample.	5-1/2	188
Dolomite, medium gray (N5), very finely megacrystalline (B-1) parting into 1-foot layers; uppermost 6 inches mottled medium gray and medium dark gray (N4) (B-1e). Sample no. 1649 at 3-1/2 feet above base.	5	182-1/[illegible]
Dolomite, medium light gray (N6), very finely megacrystalline to microcrystalline (B-1a); indistinct laminae on weathered surface. Sample no. 1648 at 1 foot above base.	1-1/2	177-1/[illegible]
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1), parting into 2-foot layers; regular parallel laminae; scattered, irregular lenses of white chert. Sample no. 1647 at 3-1/2 feet above base.	4-1/2	176
Dolomite, medium gray (N5), very finely megacrystalline (B-1a). No sample.	1-1/2	171-1/2
Dolomite, medium gray (N5) to medium light gray (N6), finely megacrystalline (B-1), parting into 6-inch to 1-foot layers; uppermost beds contain dark siliceous mottling (B-1f) and scattered equant, rounded 1/4-mm. to 1-mm. grains of quartz sand (B-1g). Samples no. 1645 at 3 feet; no. 1646 at 5-1/2 feet above base.	5-1/2	170
Dolomite, medium gray (N5), microcrystalline (B-1a), weathering yellowish gray (5Y8/1);		

	Thickness (feet) unit	total
regular parallel laminae. Sample no. 1645.	1-1/2	164-1/2
Dolomite, slowly effervescent; medium gray (N5) to medium light gray (N6) very finely megacrystalline (B-1b); wavy laminae and bands. Sample no. 1644 at 1-1/2 feet.	3	163
Dolomite, medium gray (N5), very finely megacrystalline (B-1b); indistinct laminae and bands. Sample no. 1643.	2	160
Dolomite, medium light gray (N6), very finely megacrystalline (B-1); lowermost 1-1/2 feet contains regular, parallel laminae (B-1b) and is overlain by 6-inch zone containing siliceous mottlings (B-1f). Sample no. 1642.	3-1/2	158
Dolomite, medium gray (N5), very finely megacrystalline (B-1b) parting into 2-inch layers; regular parallel laminae. Sample no. 1641.	1-1/2	154-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b); regular parallel laminae and bands; scattered nodules and stringers of dark-gray chert. Sample no. 1640 at top.	3-1/2	153
Dolomite, medium light gray (N6), very finely megacrystalline (B-1), parting into 1- to 2-foot layers; regular parallel laminae (B-1b) in lower 2 feet; subreticulate, dark, siliceous mottling in upper 2 feet (B-1f); chert, weathering rusty brown. Samples no. 1638 at 3-1/2 feet; no. 1639 at top of unit.	7	149-1/2
Chert layer (B-7), dark gray (N3), enclosing 1/4-inch to 4-inch dolomite euhedra; chert grades laterally into finely- to medium-megacrystalline dolomite (B-2) weathering medium light gray (N6). Sample no. 1637.	1	142-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b), laminated distinctly		

	Thickness (feet) unit	total
at base and indistinctly above, parting into 1-foot layers; poorly defined mud cracks in lower beds. Sample no. 1636 at base of unit.	3-1/2	141-1/
Dolomite, medium gray (N5), very finely megacrystalline to microcrystalline (B-1), parting into 1/2- to 1-foot layers; regular laminae and bands in upper 4 feet (B-1b) becoming mottled medium gray and medium light gray (N6) in lower 3 feet (B-1e). Samples no. 1633 and no. 1634 at 3-1/2 feet; no. 1635 at top of unit.	7	138
Exposures; dolomite, medium gray (N5), very finely megacrystalline (B-1); lower beds contain numerous 1/4-inch laminae of equant, rounded 1/2-mm. to 2-mm. grains of quartz sand (B-1g); upper beds contain raised, branching, cylindrical structures on bedding surfaces resembling fucoid markings. Sample no. 1631 at 0 feet; no. 1632 at top of unit. Traverse 24 feet about N65°W perpendicular to bedding strike; bedding dip 60°NW.	21	131
Exposures; alternating beds of mottled to sub-banded medium-gray (N5) to medium-light-gray, finely megacrystalline dolomite (B-1e) and beds of medium-light-gray, very-finely-megacrystalline dolomite (B-1a) weathering yellowish gray (5Y8/1). Samples no. 1629; no. 1630 at top. Traverse 19 feet about N65°W perpendicular to bedding strike; dip of bedding is 60°NW.	16-1/2	110
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b), weathering light yellowish gray (5Y8/1) parting into 1/2- to 4-foot layers; indistinct laminae; numerous stringers of white chert; discontinuous joints filled with dark chert. Sample no. 1628 at 7-1/2 feet.	8-1/2	93-1/2
Dolomite, medium light gray (N6), medium mega-		

	Thickness (feet) unit	total
crystalline, parting into 4-inch layers; equant, rounded grains of quartz and calcitic sand in brownish-weathering cement (B-1g to B-1h). Sample no. 1627.	2	85
Dolomite, medium gray (N5) to medium light gray (N6) with light- brown and pinkish streaks, finely to very finely megacrystalline (B-1), weathering yellowish gray (5Y8/1); joints filled with dark-gray chert. Samples no. 1625 at 1 foot; no. 1626 at 4 feet above base.	5	83
Dolomite, medium gray (N5), very finely megacrystalline (B-1b); regular parallel laminae. No sample.	1-1/2	78
Dolomite, medium gray (N5) to medium light gray (N6) in mottled and sub-banded distribution, finely megacrystalline (B-1e) parting into 1-foot layers; "floating," equant, rounded, 1/2-mm. to 1-mm. grains of quartz sand (B-1g) and 1/4-inch to 1-inch angular fragments of dark-gray chert. Samples no. 1624 at base; no. 1624-1/2 at 7-1/2 feet above base.	8-1/2	76-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1a). No sample.	2-1/2	69
Dolomite, medium gray (N5), very finely megacrystalline (B- 1b), parting into 1/2-foot layers; indistinct laminae. Sample no. 1623.	2-1/2	66-1/2
Dolomite, medium gray (N5) to medium light gray (N6) with pinkish and brownish streaks and laminae, finely megacrystalline (B-1), parting into 1-foot layers; equant, rounded, 1/4-mm. to 1/2-mm. grains of quartz sand in upper beds (B-1g). Samples no. 1621 at base; no. 1622 at 3.0 feet.	3	64

Base of quartzose zone (109 feet thick).

	Thickness (feet) unit	total
Dolomite, medium light gray (N6), microcrystalline (B-1b); indistinct laminae. Sample no. 1620 at top of unit.	1-1/2	61
Dolomite, medium gray (N5) to medium light gray (N6) finely megacrystalline (B-1), weathering yellowish gray (5Y8/1); recurring repetition of color distribution is apparent; mottling (B-1c) grading upward through sublaminae and -bands into zones of regular laminae (B-1b), parting into 1-foot layers. Samples no. 1617 at 2 feet; no. 1619 at 10-1/2 feet above base of unit.	11-1/2	59-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), weathering very light gray (N8), parting into 1-foot layers; indistinct laminae. Sample no. 1616 at 5 feet.	5-1/2	48
Dolomite, mottled medium gray (N5) and medium light gray (N6), finely megacrystalline (B-1e); disseminated, irregular, micro-fractures filled with white dolomite and resembling those characteristic of the coarser textures of the lower member; weathered surface displays subreticulate siliceous mottling (B-1f). Sample no. 1615.	1-1/2	42-1/2
Dolomite, medium gray (N5) with pinkish and brownish streaks, very finely megacrystalline (B-1). Sample no. 1614.	1	41
Dolomite, mottled medium gray (N5) to medium light gray (N6), very finely megacrystalline (B-1e); with indistinct laminae (B-1b). No sample.	1-1/2	40
Dolomite, medium light gray (N6), very finely megacrystalline (B-1a), weathering light gray (N7). Sample no. 1613 at 1 foot above base.	2	38-1/2

	Thickness (feet) unit	total
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), weathering very light gray, parting into 8-inch layers; regular parallel laminae. Sample no. 1612 at 1 foot above base.	2	36-1/2
Dolomite, medium light gray (N6) with pinkish and brownish patches, very finely to finely megacrystalline (B-1b), parting into 6-inch layers; indistinct laminae and bands; 6-inch-long nodules of black chert at top. Samples no. 1610 at 6 inches; no. 1611 at 6 feet above base.	7	34-1/2
Dolomite, medium gray (N5) to medium light gray (N6), microcrystalline (B-1b), parting into 1-1/2-foot layers; indistinct laminae; dark-gray-chert nodules at base; gash-weathering along irregularly spaced joints. Sample no. 169 at 6 inches above base.	3-1/2	27-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1a), weathering very light gray (N6), parting into 1/2- to 1-foot layers. No sample.	2-1/2	24
Exposures; dolomite, medium light gray (N6), very finely megacrystalline (B-1a), weathering very light gray (N8), parting into 1/2- to 1-foot layers; gash-weathered joints; bed of fine-to medium-megacrystalline dolomite (B-2a) in middle. Traverse 15 feet perpendicular to bedding strike; bedding dip 40°NW. Samples no. 166 at 4 feet; 167 at 5 feet above base of unit.	9-1/2	19-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1), parting into 2-foot layers; wavy to crinkly, medium-gray (N5) laminae and bands; 4-inch bed of dark-gray chert (B-7) in middle; 2-inch nodules of chert scattered throughout; laminated zones tend to part into		

	Thickness (feet) unit	total
3-inch layers. Samples no. 161 at 0 feet; no. 162 at 5 feet; no. 163; no. 164 at 8-1/2 feet; no. 165 at 9-1/2 feet above base.	10	10
Exposed thickness of upper member Rickenbach Formation		188
Concealed. Exposures of lower member Rickenbach dolomite in upper part. Traverse N63°W, 890 feet; bedding N25°E 40°NW.	550-575	

Stonehenge Limestone

Exposures; limestone; 1-foot to 3-foot layers of limestone ("edgewise") conglomerate in nearly vertical beds.

SECTION NUMBER 4

Epler School, Pennsylvania (No. 2) Date described: July, 1955
Date sampled: July, August, 1955
September, 1956

Location and structure of section

Type section of Epler Formation is continuous with the type section of upper Rickenbach Dolomite (section No. 3) in Bern township, Berks County, Pennsylvania (Fig. 3). All exposures stratigraphically above base of lowest limestone in the section and below concealed interval beneath first chert bed of Ontelaunee Formation are included in Epler Formation.

From eleven readings beds strike N20°E and dip 60°NW. Closely spaced rock cleavage strikes N20°E and dips 85°SE. Poles of 21 joints from Rickenbach dolomite and Epler limestone and dolomite were plotted on a Schmidt net. The most common set strikes about N80°W and dips 80° to 85°SW with several northeastward dipping surfaces. A prominent set strikes N45°E and dips 45°SE.

Where traverse data not given, unit thickness measurements were made with an 8-foot tape held perpendicular to bedding.

Section description	Thickness (feet) unit	total
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Exposures; chert, 1-foot to 2-foot layers, dark gray (N3); abundant dolomite float.	not measured	
Concealed. Traverse N33°W, 150 feet; bedding N15°E 68°NW. Parts of concealed strata exposed in sections 5, 7 and 9.	100	100
Measured thickness of Ontelaunee Formation		100
Epler Formation		
Exposures; medium-gray (N5) calcarenite (B-5a) and thin-bedded, finely-to medium-megacrystalline, light-gray (N7), laminated dolomite (B-1b).	10	798-1/2

	Thickness (feet) unit	total
Concealed. Traverse N33°W, 133 feet; bedding N15°E 68°NW. Exposure at southeast end of interval of dark-greenish-gray (50Y4/1), medium-phanerite, igneous dike weathering dark rusty brown; contacts not exposed.	90	788-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1a), weathering yellowish gray (5Y8/1), parting into 1/2- to 1-1/2-foot layers. No sample.	2-1/2	698-1/2
Limestone, medium gray (N5), calcarenitic (B-5a), irregularly banded by discontinuous, corrugated, laminae weathering yellowish gray (5Y8/1). Sample no. 16218 at 1 foot above base.	2	696
Dolomite, very slowly effervescent, medium gray (N5), very finely megacrystalline (B-1b), parting 6 inches above base; indistinct laminae. Sample no. 16217 at base.	2-1/2	694
Limestone, medium gray (N5), roughly fracturing cryptogranular with clustered and scattered crystals of sparry carbonate (B-4d); lenses of pebble calcarenite (B-5b) consisting of 2-mm. to 5-mm., elongate, rounded limestone pebbles surrounded by yellowish-gray (5Y8/1)-weathering dolomite; unit is separated into irregular bands by thin, discontinuous, corrugated dolomitic laminae. Samples no. 16215 at 5 feet; no. 16216 at 8 feet above base.	12	691-1/2
Dolomite, very slowly effervescent, medium gray (N5), very finely megacrystalline (B-1b), parting into 1/2- to 1-1/2-foot layers; indistinct laminae. Sample no. 16214 at 1-1/2 feet above base.	3-1/2	679-1/2
Exposures; predominant lithology is medium-gray (N5), roughly fracturing cryptogranular limestone (B-4a) with scattered 1/2-mm. crystals of sparry carbonate and scattered lenses		

	Thickness (feet) unit	total
of calcarenite; numerous 1-inch to 4-inch zones of irregular, wavy to corrugated, 1/8-inch, medium-dark-gray (N4), siliceous laminae separating irregular 2-inch bands of silty, parallel- and cross-bedded laminae; unit contains at least 3 zones of interconnected lobes, stringers and lenses weathering with yellowish-gray (5Y8/1), pitted surfaces and arranged in sub-bands (B-1h); amount of calcarenite increases in vicinity of dolomitic zones, the coarser clasts surrounded by dolomite. Samples no. 16210 at 3 feet; no. 16211 at 12 feet; no. 16212 at 28 feet; no. 16213 at 41 feet above base.	42	676
Dolomite, medium gray (N5), very finely megacrystalline, parting 1 foot above base; scattered medium-megacrystalline clusters and stringers that effervesce slowly. Sample no. 16209 at 6 inches above base.	1-1/2	634
Limestone, medium gray, roughly-fracturing cryptogranular (B-4a); scattered lenses of bioclastic, pebble calcarenite (B-5); irregularly banded by discontinuous, medium-dark-gray (N4) laminae. Sample no. 16208 at 10 feet above base.	11-1/2	632-1/2
Limestone, medium gray (N5); bioclastic, pebble calcarenite (B-5c) with 2-mm.- to 2-cm.-long, elongate, subrounded limestone pebbles; unit irregularly banded by discontinuous corrugated, silty-argillaceous laminae; scattered small nodules of dark-gray (N3) chert; zone of dolomitic mottling (B-5b) at top of unit is truncated by scour surface at base of overlying unit. Sample no. 16206 at 3 feet; no. 16207 at top of unit.	5	621
Limestone, medium gray (N5), roughly-fracturing cryptogranular with scattered 1-mm. crystals of sparry carbonate (B-4); lenses of calcarenite increase upward into 1-1/2 feet of predomin-		

	Thickness (feet) unit	total
antly bioclastic calcarenite (B-5b) with interclastic dolomite; irregular streaks and laminae in lower horizons grade upward into 1/2-inch irregular, siliceous, laminae separating irregular bands of silty parallel- to cross-bedded laminae (B-4a); the proportion of argillaceous laminae increases upward paralleling the increase in calcarenite; laminae take on shiny-black (N1) weathering appearance in upper part. Samples no. 16202 at 2 feet; no. 16203 at 6-1/2 feet; no. 16204 at 11 feet; no. 16205 at 14 feet above base.	15	616
Limestone, medium gray (N5), roughly fracturing cryptogranular (calcisiltite to fine calcarenite in part) with scattered 1/4-mm. crystals of sparry carbonate (B-1b); unit characterized by irregular bands and stringers of dolomite weathering with pitted surfaces where well-rounded calcite grains weather inward; dolomite bands make up 80 to 85 percent of the surface area (B-1b) in the lower 1-1/2 feet. Samples no. 16200 at 6 inches above base; no. 16201.	2-1/2	601
Limestone, medium gray (N5), parting into 1/2-foot layers; fine to medium calcarenite (B-5); lenses and thin beds of calcarenite with 2-mm.- to 8-cm.-long, elongate, subangular, laminated limestone fragments; irregularly banded by discontinuous, corrugated, siliceous laminae weathering black (N1). Samples no. 16198 at 3 feet; no. 16199 at 5-1/2 feet above base.	10-1/2	598-1/
Limestone, medium gray (N5); fine to medium calcarenite (B-5); lower 8 inches consists of dolomite with pitted, yellowish-gray (5Y8/1)-weathering surface (B-5b to B-1b); this zone grades into sub-banded dolomite (B-5b to B-5a) in upper 8 inches with similar pitted appearance caused by selective solution of calcite sand grains; unit is gradational with adjacent units. Samples no. 16196 at base; no. 16197		

	Thickness (feet) unit	total
at top of unit.	1-1/2	588
Limestone, medium gray (N5), roughly fracturing cryptogranular (calcisiltitic), parting into 6-inch layers; numerous lenses of bioclastic, pebble calcarenite (B-5c) becoming 4-inch beds above; irregularly banded by 1/4-inch discontinuous, wavy, siliceous laminae weathering shiny black (N1); specimens of <u>Ophileta</u> sp., <u>Raphistoma</u>? sp., <u>Maclurites</u>? sp., <u>Hormotoma</u>? sp., diparelasmid brachiopods and bathyurid trilobites have been uncovered in these and the immediately underlying beds. Samples no. 16192 at 2-1/2 feet; no. 16193 at 5 feet; no. 16194 at 7 feet; no. 16195 at 10 feet above base.	13-1/2	586-1/2
Limestone; medium gray (N5); fine to medium calcarenite (B-5a), parting into discontinuous 4-inch layers; irregularly banded by 1/4-inch irregular laminae of dolomite grading into a predominantly dolomitic 2-foot layer 5-1/2 feet below top of unit; numerous gastropod sections. Samples no. 16188 at 3 feet; no. 16189 at 3-1/2 feet; no. 16190 at 7-1/2 feet; no. 16191 at 12 feet above base.	12-1/2	573
Exposures; limestone, parting into 3- to 4-inch layers; medium to coarse bioclastic calcarenite (B-5a) with 5-mm.- to 2-1/2-cm. subequant, subrounded pebbles; irregularly-banded by 1/8-inch, wavy laminae weathering dark yellowish orange (10YR6/6). Sample no. 16187.	2-1/2	560-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4d) with lenses of fine to medium calcarenite; layer of pebble calcarenite (B-5a) at top with 3-inch regular dolomite bands; bands contain calcite grains which weather inward; unit is irregularly-banded by 1/8-inch, corrugated, silty-argillaceous laminae. Sample no. 18186 at top of unit.	3-1/2	558

	Thickness (feet) unit	total
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 1/2- to 1-foot layers; indistinct laminae in lower 2 feet and distinct slowly effervescent laminae in upper 6 inches; lower contact abrupt and unwelded. No sample.	2-1/2	554-1/
Limestone, medium gray (N5), roughly fracturing cryptogranular with scattered 1/2-mm. crystals of sparry carbonate (B-4); several thin zones of pebble calcarenite (B-5); numerous irregular laminae and corrugated streaks. Sample no. 16185 at 1 foot above base.	2	552
Dolomite, calcitic (B-1c), medium gray (N5), very finely megacrystalline, freely effervescent; regular parallel laminae weathering with thinly ridged surface; several V-shaped structures cut laminae and resemble mudcracks. Sample no. 16184 at top of unit.	3	550
Limestone, medium gray (N5), roughly fracturing cryptogranular with disseminated 1/8-mm. and scattered 1/2-mm. to 1-mm. crystals of sparry carbonate (B-4d); several small lenses of pebble calcarenite (B-5); very irregular, anastomosing, siliceous laminae weathering into low relief. Sample no. 16183 at 2-1/2 feet above base.	5	547
Dolomite, medium gray (N5), very finely megacrystalline (B-1), parting into 2- to 3-foot layers; irregular 1-inch bands of fine doloarenite; zone of dark-gray (N3) chert nodules with an irregular 2-inch chert bed 4-1/2 feet above base. Sample no. 16182 at 1 foot above base.	7-1/2	542
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4d) with disseminated 1/8-mm. and scattered 1/2-mm. to 1-mm. crystals of sparry carbonate; numerous fine bioclastic		

	Thickness (feet) unit	total
calcarenite lenses; irregularly banded by 1/8-inch to 1/4-inch, corrugated, siliceous laminae weathering into low relief; contacts abrupt and unwelded. Sample no. 16181 at 1-1/2 feet above base.	2	534-1/2
Dolomite, very slowly effervescent, medium gray (N5), very finely megacrystalline (B-1b); 1/2-inch to 3-inch bands of regular parallel laminae; 2 inches of medium-dark-gray (N4) dolomite at base with shaly partings; contacts abrupt and unwelded. No sample.	1	532-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4) with several lenses of pebble calcarenite; irregular 1/8-inch streaks and laminae; contact with overlying unit is abrupt and unwelded. No sample.	1-1/2	531-1/2
Dolomite, moderately effervescent, medium dark gray (N4), very finely megacrystalline (B-1c); regular parallel laminae weathering into thinly ridged surface. Sample no. 16180 at base.	2	530
Limestone, medium gray (N5), roughly fracturing cryptogranular with disseminated 1/8-mm. crystals of sparry carbonate (B-4); scattered lenses of pebble calcarenite (B-5); 2-foot layer of 1/8-inch to 1/2-inch dolomitic laminae (B-5a) beginning 1-1/2 feet above the base and grading into laminated dolomite in upper 2 feet (B-1c?); laminated zone contains 1/4-inch to 1/2-inch stringers of limestone. No sample.	5-1/2	528
Limestone, medium gray (N5), roughly fracturing cryptogranular with disseminated 1/4-mm. crystals of sparry carbonate (B-4d); scattered lenses of pebble calcarenite (B-5); irregularly banded by micro-folded laminae with axial planes parallel to a closely spaced rock cleavage; gradational with overlying unit.		

	Thickness (feet	
	unit	tota
Sample no. 16179 at 1 foot 8 inches above base.	3-1/2	522-1/
Dolomite, slowly effervescent, medium dark gray (N4), very finely megacrystalline (B-1a); several 1/8-inch, discontinuous laminae weathering into low relief. Sample no. 16178.	1	519
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-5a); numerous lenses of pebble calcarenite consisting of 2-mm. to 1-mm., equant pebbles surrounded by a fine-to-medium-calcarenite matrix; irregularly banded by 1/8-inch, irregular laminae weathering yellowish gray (5Y8/1). Sample no. 16177 at top.	2-1/2	518
Dolomite, very slowly effervescent, medium gray (N5), very finely megacrystalline (B-1a); contacts abrupt and unwelded. Sample no. 16176.	1	515-1/
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3d); 1/2-inch, lensing laminae weathering yellowish gray (5Y8/1). No sample.	1/2	514-1/
Dolomite, medium gray (N5), very finely megacrystalline (B-1a), weathering yellowish gray (5Y8/1); contact with overlying unit abrupt and unwelded. No sample.	1-1/2	514
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3d); 1/4-inch, lensing laminae weathering yellowish gray (5Y8/1). No sample.	1-1/2	512-1/
Dolomite, medium gray (N5), finely megacrystalline (B-1a), weathering yellowish gray (5Y8/1); gradational with overlying unit; separated from underlying unit by abrupt unwelded contact. No sample.	1-1/2	511
Limestone, medium gray (N5), smoothly frac-		

	Thickness (feet) unit	total
turing cryptogranular (B-3d); 1/4-inch, lensing laminae weathering yellowish gray (5Y8/1). No sample.	1-1/2	509-1/2
Dolomite, slowly effervescent, medium gray (N5), very finely megacrystalline (B-la), parting into 1-foot layers; gradational with overlying unit; separated from underlying unit by abrupt, unwelded contact. Sample no. 16175, at 6 inches above base.	5	508
Limestone, medium gray (N5), smoothly fracturing cryptogranular with scattered 1-1/2-mm. crystals of sparry carbonate (B-3); several small lenses of pebble calcarenite (B-5); irregular 1/4-inch to 1/2-inch bands separated by 1/4-inch, lensing laminae weathering yellowish gray (5Y8/1). Sample no. 16174.	1-1/2	503
Dolomite, medium gray (N5), very finely megacrystalline (B-lb to B-lc), parting into 1-foot layers; regular parallel laminae; several 2-inch to 3-inch shaly bands with indistinct mudcracks; contacts welded. Sample no. 16173 at 2-1/2 feet above base.	5-1/2	501-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4d); numerous lenses of pebble calcarenite (B-5) in which pebbles are oriented with long axes parallel to prominent cleavage trace; lower 1 foot irregularly banded by 1/4-inch to 1/2-inch laminae weathering into low relief. Samples no. 16171 at 1 foot above base; no. 16172 at top.	6-1/2	496
Dolomite, medium gray (N5) to medium dark gray (N4), finely megacrystalline (B-lb or B-lc); regular parallel laminae along which shaly partings develop; contacts gradational and unwelded. Samples no. 16169 at 3 feet; no. 16170 at 3-1/2 feet above base.	4	489-1/2
Limestone (B-4 and B-5) and dolomitic-mottled		

	Thickness (feet) unit	total
limestone (B-4b); predominant lithology is medium gray (n5), roughly fracturing cryptogranular limestone, irregularly banded by 1/4-inch corrugated, siliceous laminae which weather into relief; the uppermost parting is mudcracked and underlain by a 6-inch zone containing lenses of pebble calcarenite; calcarenite underlain by 5-inch bed of stromatolites of the cryptozoon type overlying a 1-foot bed of dolomite (B-1); zones of dolomitic limestone containing yellowish-gray (5Y8/1)-weathering sub-bands and interspersed lobes, lenses and cylindrical structures resembling fucoids occur at the base of the dolomite unit and at 6-1/2 feet, 11-1/2 feet, and 20-1/2 feet below the top of the unit. Samples no. 16165 at 10-1/2 feet; no. 16166; no. 16167, and no. 16168 at top.	21	485-1/
Dolomite, very slowly effervescent, medium gray (N5), very finely megacrystalline (B-1a), parting into 1-foot layers; contacts gradational and unwelded. Sample no. 16164 at 1 foot above base.	2-1/2	464-1/
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4b), parting 4 feet above base; alternating 2-foot layers of dolomitic-mottled and of irregularly banded limestone; mottling is in lobes, lenses and cylinders; bands are separated by 1/4-inch, corrugated, dark-gray (N3), siliceous laminae, anastomosing in the upper 4 feet; bands are associated with lenses of pebble calcarenite (B-5). Samples no. 16161 at 1 foot; no. 16162 at 4 feet; no. 16163 at 10 feet above base.	13	462
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c), parting 3 feet above base; numerous lanses of pebble calcarenite (B-5a); irregularly banded by wavy to corrugated laminae, weathering yellowish gray (5Y8/1) to dark yellowish orange (10YR6/6). Samples no. 16159 at 1 foot; no. 16160 at 4		

	Thickness (feet) unit	total
feet above base.	5	449
Limestone, medium gray (N5), roughly fracturing cryptogranular with scattered 1/4-mm. crystals of sparry carbonate (B-4); irregularly banded by wavy laminae; several 4-inch-long, dark-gray (N1) chert nodules; limestone weathering medium light gray (N6). Sample no. 16158.	1/2	444
Dolomite, very slowly effervescent, medium light gray (N6), finely to medium megacrystalline (B-1b), weathering yellowish gray (5Y8/1), parting into 1- to 1-1/2-foot layers (N5), regular parallel laminae. Samples no. 16156 at 3 inches; no. 16157 at 8 inches above base.	4	443-1/2
Dolomite, medium dark gray (N4), finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1), parting into 1-foot layers; regular parallel laminae and welded styolitic seams. Sample no. 16155 at 4-1/2 feet above base.	6-1/2	439-1/2
Limestone, very finely megacrystalline; lenses and beds of fine to medium bioclastic calcarenite (B-5c); irregularly banded by 1/4-inch, discontinuous, medium-dark-gray (N4), silty-argillaceous laminae; several 1/8-inch to 1-inch zones of rounded 1/8-mm. to 1/2-mm. grains of quartz sand at base. Samples no. 16153 at base; no. 16154 at 2 feet above base.	4	433
Dolomite, calcitic (B-1d); 1-inch-thick, anastomosing, medium-gray (N5), very finely megacrystalline dolomite bands make up about 70 percent of surface area; bands weather yellowish gray (5Y8/1) with pitted surfaces caused by selective solution of grains, fragments and irregular lenses of calcite; calcarenite and silty cross-beds visible in calcite lenses. Sample no. 16152 at 6 inches above base.	2-1/2	429

	Thickness (fee unit	tota
Dolomite, medium gray (N5) to medium light gray (N6), finely megacrystalline (B-1b to B-1c), parting into 1-foot layers separated by 2-inch, dark-gray, shaly layers; regular parallel laminae. Sample no. 16151 at 4-1/2 feet above base.	6	426-1/
Limestone, roughly fracturing cryptogranular (B-4d), parting into 4- to 6-inch layers; irregular streaks and laminae weathering light brown (5YR5/6); dark-gray, hard, shaly interpartings at contacts. Sample no. 16150 at top of unit.	2	420-1/
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1); regular parallel laminae; 3 inches of shaly, medium-dark-gray (N4), laminated, hard dolomite at the base weathering light brown (5YR5/6). Sample no. 16149 at base of unit.	1-1/2	418-1/
Limestone, medium gray (N5); bioclastic pebble calcarenite (B-5c); irregularly banded by discontinuous, wavy 1/8-inch, siliceous laminae weathering into strong relief. Sample no. 16148.	1/2	417
Limestone, medium gray (N5) to medium dark gray (N4), roughly fracturing cryptogranular with scattered and clustered 1/4-mm. to 1/2-mm. crystals of sparry carbonate (B-4d); scattered bioclastics; 6-inch lenses of pebble calcarenite (B-5) at top; anastomosing 1/4-inch to 1-inch medium-gray (N5) bands. Samples no. 16146 at 6 inches; no. 16147 at top of unit.	1-1/2	416-1/2
Dolomite, very slowly effervescent, medium gray (N5) to medium dark gray (N4), very finely megacrystalline (B-1), weathering yellowish gray (5Y8/1); irregular 1/8-inch zones of 1/2-inch siliceous laminae; 1/8-inch		

	Thickness (feet) unit	total
zones of 1/8-inch-mm. to 1/2-mm., rounded grains of quartz sand.	1/2	415
Dolomite, very slowly effervescent, medium gray (N5), finely megacrystalline (B-1b); indistinct, discontinuous laminae. Sample no. 16145 at top of unit.	1-1/2	414-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular with scattered 1/8-mm. crystals of sparry carbonate (B-4b), parting into 1-foot layers; thin beds and lenses of calcarenite (B-5); several calcirudite (B-6) beds; lower 7 feet characterized by dolomitic mottling weathering yellowish gray (5Y8/1) and concentrated in 1-inch to 4-inch sub-bands bounded by 1/8-inch laminae weathering dark yellowish brown (10YR4/2) and black (N1); unit grades into overlying unit through zone of 1/2-inch to 2-inch, very finely megacrystalline, anastomosing bands weathering yellowish gray; nodules and rosettes of dark chert in upper 1 foot. Samples no. 16141 at 2 feet; no. 16143 at 15-1/2 feet above base.	16-1/2	413
Dolomite, slowly effervescent, medium gray (N5), very finely megacrystalline (B-1b); regular parallel laminae. Sample no. 16140 (16-C1-8) at base.	1-1/2	396-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4b); parting into 1-foot layers; cylindrical, branching intergrowths weathering yellowish gray (5Y8/1); mottling arranged in sub-bands; dolomite percentage increases toward top (B-1d). Sample no. 16139 at 1 foot above base. Samples no. 16-C1-1 at base; no. 16-C1-2 at 6 inches; no. 16-C1-3 at 1 foot; no. 16-C1-4 at 1-1/2 feet; no. 16-C1-5 at 2 feet; no. 16-C1-6 at 2-1/2 feet; no. 16-C1-7 at 3 feet above base.	3-1/2	395
Dolomite, medium light gray (N6), very finely		

	Thickness (fee	
	unit	tota
megacrystalline (B-1b), parting into 1- to 2-foot layers; regular parallel laminae. No sample.	5-1/2	391-1
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c), irregularly banded by 1/8-inch laminae weathering dark yellowish brown (10YR4/2); 1- to 2-inch irregular layers of pebble calcarenite (B-5). Sample no. 16138 at 9 inches above base.	1-1/2	38(
Dolomite, very slowly effervescent, medium light gray (N6), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1); regular laminae and bands. Sample no. 16137 at 1 foot above base.	2	384-1/
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4d); 1-inch to 2-inch layers of pebble calcarenite (B-5) bounded by 1/8-inch, black-weathering laminae. Sample no. 16136 at top.	2	382-1/
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 1/2- to 1-foot layers; regular laminae and punky-weathering bands. Sample no. 16135 at 3 feet above base.	5	380-1/
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c to B-4b); 1-foot zone of discontinuous laminae weathering dark yellowish brown (10YR4/2) and 1-inch to 4-inch long, dark-gray chert nodules at base; upper 1 foot contains lobate mottling weathering yellowish gray (5Y8/1) and grading into overlying unit. No sample.	2	375-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 1- to 2-foot layers; regular parallel laminae; 1-foot zone at base of very irregular, siliceous stringers weathering into strong relief. Samples no.		

	Thickness (feet) unit	total
16133 at 6 inches; no. 16134 at 3-1/2 feet above base.	6	373-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c to B-4b); 1- to 1-1/2-foot zones at top and base of unit with 1/2-inch to 1-inch bands separated by 1/8-inch to 1/2-inch regular, wavy, laminae weathering yellowish gray (5Y8/1); upper laminated zone is underlain by 5 feet of irregular stringers, small lenses and lobes of dolomite weathering yellowish gray; mottled zone is underlain by 4 inches of pebble calcarenite (B-5). Samples no. 16130 at 0 feet; no. 16132 at 4 feet above base.	8	367-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b to B-1c), parting into 1/2- to 2-foot layers separated by 1/4- to 1/2-inch, black-weathering laminae; 1/8-inch to 1-inch regular bands separated by somewhat thinner, effervescent laminae; several scattered dark-gray (N3) chert stringers. Sample no. 16129 at 3-1/2 feet above unit.	5-1/2	359-1/2
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b); calcarenite in lower part; numerous dolomitic stringers weathering yellowish gray (5Y8/1); unit grades into overlying unit through 6 inches of dolomite mottling and underlying unit through 4 inches of dolomitic stringers and mottling in sub-banded distribution. Sample no. 16128 at 1-1/4 feet above base.	2-1/2	354
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b); weathering yellowish gray (5Y8/1); indistinct regular parallel laminae. Sample no. 16127 at 1-3/4 feet above base.	3-1/2	351-1/2
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3d) with scattered and		

	Thickness (fee unit	tot
clustered 1/4-mm. to 1/2-mm. crystals of sparry carbonate; several lenses of pebble calcarenite (B-5); irregularly banded by 1/4-inch laminae and streaks weathering yellowish gray (5Y8/1). Sample no. 16126 at 1 foot above base.	4-1/2	34
Dolomite, very slowly effervescent, medium light gray (N6), very finely megacrystalline (B-1b), parting into 2-foot layers; indistinct laminae; scattered nodules and stringers of white chert; nodules of dark-gray (N3) chert 3 inches below top. Sample no. 16125 at 3 feet above base.	6	343-1
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c); irregularly banded by 1/4-inch, irregular laminae weathering dark yellowish brown (10YR4/2) to black (N1). No sample.	1/2	337-1,
Dolomite, moderately effervescent in part, medium light gray (N6), very finely megacrystalline (B-1a); 1-inch to 3-inch circular masses of black chert surrounding centers of white dolomite. Sample no. 16124 at 2 feet above base.	6	33
Limestone, medium gray (N5), smoothly fracturing cryptogranular with scattered crystals of sparry carbonate (B-3b); scattered bioclastics; sub-banded distribution of irregular laminae and streaks weathering yellowish gray (5Y8/1). Sample no. 16123, 3 feet above base.	4	331
Dolomite, medium gray (N5), very finely megacrystalline (B-1b); regular parallel laminae; gradational contacts. No sample.	1/2	327
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b to B-5b) in part with scattered bioclastics, indistinct finely calcarenitic textures, parting into 1/2- to 1-foot layers;		

	Thickness (feet) unit	total
sub-banded distribution of lensing intergrowths weathering with pitted, yellowish-gray (5Y8/1) surface; pitting caused by selective solution of fine to medium calcite sand. Samples no. 16121 at 6 inches; no. 16122 at 2-1/2 feet above base.	4	326-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1); regular parallel laminae; contacts gradational. Sample no. 16-C2-7 at 6 inches above base.	1	322-1/2
Limestone, medium gray (N5) to medium light gray (N6), smoothly fracturing cryptogranular (B-3 to B-5d) with scattered 1/2-mm. crystals of sparry carbonate; lenses of pebble calcarenite (B-6); numerous gastropod sections averaging 1/4 inch to 1/2 inch in diameter; intergranular dolomite concentrated in stringers and sub-bands and weathering yellowish gray (5Y8/1). Sample no. 16120 at 1/2 foot. Samples no. 16-C2-7 at 6 inches above base; no. 16-C2-8 at top.	1	321-1/2
Dolomite, moderately effervescent, medium light gray (N6), very finely megacrystalline (B-1d); enclosing irregular 1/2-inch to 1-inch elongate lenses of calcite and scattered bioclastics; gradational with overlying limestone. Sample no. 16119 at 15 feet. Samples no. 16-C2-4 at 0 feet; no. 16-C2-5 at 6 inches above base; no. 16-C2-6 at top.	1	320-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c); scattered bioclastics and lenses of calcarenite; 1/4-inch to 1-inch, very-finely-megacrystalline bands weathering dark yellowish brown (10YR4/2) to black (N1) increasing in proportion upward and grading into overlying unit. Samples no. 16-C2-2 at 0 feet; no. 16-C2-3 at 6 inches.	1	319-1/2
Limestone, medium gray (N5); bioclastic pebble		

	Thickness (feet) unit	total
calcarenite (B-5b); irregular laminae and lobes of dolomite arranged in sub-banded distribution; gradational with overlying unit. Sample no. 16118. Sample no. 16-C2-1 at base.	1/2	318-1/
Dolomite (B-1b), moderately effervescent medium gray (N5) to medium dark gray (N4), parting into 2- to 6-inch layers; regular parallel laminae and bands; 1-inch to 2-inch masses of chert at base. Sample no. 16117 at 1 foot above base.	3	318
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b) in part, parting into 3-foot layers; 2-inch to 4-inch interbeds of bioclastic, pebble, calcarenite (B-5); numerous zones of siliceous laminae and streaks; laminae weather black and become subreticulate 1/4-inch laminae at top contacts gradational through zones of mottling weathering yellowish gray (5Y8/1). Samples no. 16116 at top; no. 16115 at 6 feet above base.	8	315
Dolomite, slowly effervescent, medium gray (N5) to dark gray (N4), very finely megacrystalline (B-1b); regular parallel laminae. Sample no. 16114.	1-1/2	307
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3) in part, parting into 1-1/2-foot layers; several 4-inch layers of bioclastic calcarenite (B-5) with numerous gastropods. Sample no. 16113 at top of unit.	3	305-1/2
Dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline (B-1b), parting into 2-foot layers; weathering yellowish gray (5Y8/1) with indistinct wavy laminae. Sample no. 16112 at 2 feet.	4-1/2	302-1/2
Limestone, medium gray (N5); interbedded 6-inch to 1-foot layers of silty-argillaceous-laminated, fine to medium bioclastic pebble calcar-		

	Thickness (feet) unit	total
enite (B-5) and 1-foot to 1-1/2 foot layers of roughly fracturing cryptogranular limestone (B-4b) with 1/16-inch to 1/4-inch, lensing dolomite intergrowths in sub-banded distribution; dolomite zones overlie the calcarenite zones; 6-inch zone of dark chert nodules 1/2 foot above base. Samples no. 16110 at 6 inches; 16111 at top.	4	298
Dolomite, medium light gray (N6), very finely megacrystalline (B-1), parting 1-1/2 feet above base; scattered, rounded grains of quartz sand; 1-inch zone of dark-gray chert nodules and stringers 2 inches above base. Sample no. 16109 at 1-1/2 feet above base.	2	294
Limestone; pebble calcarenite (B-5c) in lowermost 3 inches and in 1-1/2-foot zone 3 inches below top; 6-inch layer of 1/4-inch to 1/2-inch, subreticulate black-weathering bands above lower calcarenite; upper calcarenite (B-5b) contains dolomite stringers and lenses which grade upward into 3 inches of lensing subreticulate laminae weathering yellowish gray (5Y8/1) which in turn grade into overlying unit. Samples no. 16106 at 0 feet; no. 16107 at 1-1/4 feet; no. 16108 at top.	2-1/2	292
Dolomite, slowly effervescent in part, medium light gray (N6), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1), parting into 2-1/2-foot layers; regular parallel laminae. Sample no. 16105 at 5 feet above base.	9	289-1/2
Limestone, medium gray (N5); alternating zones of roughly fracturing cryptogranular limestone (B-4c) with 1/4-inch, yellowish-gray (5Y8/1)-weathering, anastomosing, laminae and 4-inch zones with 1/8-inch to 1-inch, equant to elongate subrounded limestone pebbles in dolomite matrix (B-5b). Sample no. 16104.	2	280-1/2

	Thickness (feet) unit	total
Concealed.	2	278-1/
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4), parting into 1-foot layers; 3-inch zone of pebble calcarenite (B-5) at top; 1/4-inch anastomosing siliceous laminae throughout. No sample.	3-1/2	276-1/
Exposures; laminated dolomite (B-1) and dolomitic-laminated and -banded limestone grading through a dolomitic-mottled zone into overlying unit. No sample.	1-1/2	273
Limestone, medium gray (N5), roughly fracturing cryptogranular with scattered crystals of sparry calcite (B-4d and B-4b); 1 foot of 1/4-inch, subreticulate to anastomosing, black-weathering siliceous laminae in middle; dolomite mottling at base and top; upper mottling zone contains cylindrical branching structures resembling fucoids. No sample.	1-1/2	271-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1); laminae and bands. No sample.	2	270
Limestone, medium light gray (N6), smoothly-fracturing cryptogranular (B-3) in part with scattered 1/4-mm. crystals of sparry calcite; parting 1 foot above base; scattered bioclastics; irregular silty-argillaceous streaks and thin laminae; 4 inches of dolomitic mottling (B-3b) at top; 1 foot of discontinuous 1/8-inch to 1/4-inch yellowish-gray (5Y8/1)-weathering laminae separating 2-inch zones of bioclastic calcarenite (B-5) at base. Samples no. 16102 at 0 feet; no. 16103 at 2-1/2 feet above base.	3	268
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b), parting 1 foot above base; very irregular yellowish-gray (5Y8/1)-weathering laminae and mottling		

	Thickness (feet) unit	total
increasing in proportion toward top (B-1d). Samples no. 16101 in upper 1 foot; no. 16100 at base.	2-1/2	265
Concealed.	3	262-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1a), weathering yellowish gray (5Y8/1). No sample.	1	259
Exposures; calcarenite and dolomite-mottled limestone with 6-inch dolomite interlayers.	3-1/2	258
Limestone, medium gray (N5); medium to coarse bioclastic calcarenite (B-5a to B-5b), parting into 6-inch layers in lower 1 foot; discontinuous, laminae and interclastic dolomite weathering yellowish gray (5Y8/1); 1/2-inch dolomitic laminae in lower 1 foot. Sample no. 1699 in upper 1 foot; no. 1698 in lower 1 foot.	2	254-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b), laminated distinctly in upper 1-1/2 feet and indistinctly below, parting into 1/2-foot layers in lower 1-1/2 feet. No sample.	3	252-1/2
Limestone, medium gray (N5) to medium light gray (N6), smoothly fracturing cryptogranular (B-3) with scattered crystals and clusters of sparry calcite; lower 1 foot of lobate, dolomitic mottling arranged in sub-bands and grading into yellowish-gray (5Y8/1)-weathering laminae and streaks in upper 1 foot (B-3b); upper 1 foot contains scattered bioclastics. Samples no. 1696 at 0 feet; no. 1697 at top.	2	249-1/2
Dolomite, very slowly effervescent, medium light gray (N6) very finely megacrystalline (B-1b), parting into 2-foot layers; medium-gray (N5) laminae and several 1-inch bands. Sample no. 1695 at 2-1/2 feet above base.	4-1/2	247-1/2

	Thickness (feet) unit	total
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c) with scattered 1/2-mm. to 1-mm. crystals of sparry calcite, parting 2-1/2 feet above base; medium-light gray (N6), irregular bands and laminae weathering yellowish gray (5Y8/1) and grading into overlying unit. Sample no. 1694 at 2-1/2 feet above base.	6	243
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b), parting into 1-1/2- to 2-foot layers; weathering yellowish gray (5Y8/1); regular parallel laminae. Sample no. 1693 at 8-1/2 feet above base.	10-1/2	237
Limestone, medium gray (N5), to medium light gray (N6), smoothly fracturing cryptogranular (B-3) in part; scattered lenses of pebble calcarenite with interclastic dolomite; indistinct mudcracking at top of unit; lower 1-1/2 feet contains very irregular streaks and laminae weathering dark yellowish brown (10YR4/2) to black (N1). Sample no. 1692 at top.	2	226-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 3-inch layers in lower 1 foot; indistinct laminae; gradational with overlying unit through zone of dolomitic mottling. No sample.	2	224-1/2
Limestone, medium light gray (N6), smoothly fracturing cryptogranular (B-3) in part with disseminated and clustered 1/4-mm. to 1/2-mm. crystals of sparry calcite; 2-inch zone of bioclastic pebble calcarenite (B-5) at base; very irregular, wavy, laminae weathering dark yellowish brown (10YR4/2) to black (N1). Sample no. 1691 at 2 inches above base.	1	222-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1), parting into 1- to 3-foot layers; regular parallel laminae; 6-inch- to 1-foot-long, dark-gray (N3) chert masses and stringers		

	Thickness (feet) unit	total
at base. Sample no. 1690 at 6 feet above base.	15-1/2	221-1/2
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3) in part with clustered 1/2-mm. crystals of sparry carbonate; scattered lenses of fine, bioclastic calcarenite (B-5) including numerous thin-shelled, 1/4-inch to 1/2-inch gastropod sections; 4-inch zone of yellowish-gray (5Y8/1)-weathering mottling and irregular bands (B-4b) in middle of unit. Samples no. 1689 at 2 feet; no. 1688 at 1-1/2 feet above base.	4	206
Dolomite, slowly effervescent, medium light gray (N6), very finely megacrystalline (B-1b), parting into 1/2- to 2-foot layers; regular laminae; 1-foot zone 2-1/2 feet above base containing 1/4-inch to 2-inch, elongate, subangular, laminated dolomite fragments. Sample no. 1687 at 3 feet above base.	5-1/2	202
Limestone, medium gray (N5); fine calcarenite (B-5b); lobes and lenses of interclastic dolomite weathering yellowish gray (5Y8/1); 2-inch to 4-inch long stringers and nodules of dark-gray (N3) chert; unit grades upward and laterally into dolomite. Sample no. 1686.	1	196-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b); regular parallel laminae; contact with overlying unit abrupt and welded. Sample no. 1685 at 3 feet above base.	3-1/2	195-1/a
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c); 6 inches of irregular dolomitic bands at base followed above by 1 foot of irregular dolomitic laminae; laminated zone overlain by 8 inches of lobate mottling concentrated in sub-bands (B-4b) and intermixed with subordinate calcarenite. Samples no. 1684 at top; no. 1683 at 2 feet above base.	3	192
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b); regular parallel lam-		

	Thickness (feet) unit	total
inae, grading into banded zone at base of overlying unit; abrupt welded contact below. No sample.	1-1/2	189
Limestone, parting into 1-foot layers in lower 3-1/2 feet; unit consists of two cycles composed of repetitions of the following lithologies; zone containing laminated, irregular dolomitic bands at base (B-4c) overlain sharply by a thin layer of pebble calcarenite (B-5b) with interclastic dolomite; dolomite proportion increases upward into zone of dolomitic-mottled cryptogranular limestone (B-4b) overlain by anastomosing 1/8-inch dolomitic laminae. Samples no. 1678 at 0 feet; no. 1679 at 2-1/2 feet; no. 1680 at 3 feet; no. 1681 at 3-1/2 feet above base; no. 1682 at top of unit.	6	187-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4a) with scattered 1/4-mm. crystals of sparry carbonate; scattered pebble calcarenite (B-5) lenses; irregular, wavy laminae weathering dark yellowish brown (10YR4/2) increase in proportion upwards from base. Sample no. 1677 at 1 foot above base.	2	181-1/2
Dolomite, slowly effervescent, medium gray (N5), very finely megacrystalline (B-1b); irregular laminae at base; scattered nodules of white chert. Sample no. 1676 at top.	1-1/2	179-1/2
Limestone, medium gray (N5) to medium light gray (N6), smoothly fracturing cryptogranular (B-3b) in part; lenses of pebble calcarenite (B-5); discontinuous yellowish-gray (5Y8/1)-weathering laminae grade into lobes and lenses of dolomite at base of unit. Samples no. 1675 at top; no. 1674 at 4 feet above base; no. 1673 at base.	5	178
Dolomite, calcitic (B-1c), very finely megacrystalline, parting into 1/2- to 1-1/2-foot		

	Thickness (feet) unit	total
layers; regular parallel laminae weathering into thinly ridged surface; two 6-inch layers of medium-gray (N5), finely megacrystalline dolomite weathering with pitted surface (B-1h); pitting caused by selective solution of rounded calcite sand grains. Sample no. 1672 at top.	3	173
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b to B-5b) in part with scattered and clustered 1/2-mm. crystals of sparry carbonate, parting into 1/2- to 2-foot layers; irregular dolomite bands, laminae and mottling increasing in proportion upward from base grade into overlying unit; the weathered surfaces of the bands are pitted with depressions 1/4-mm. to 1/2-mm. in diameter caused by selective solution of calcite sand grains. Samples no. 1671 at 55 feet above base; no. 1670 at base.	6-1/2	170
Dolomite, very slowly effervescent, medium gray (N5), very finely megacrystalline (B-1b), parting 1 foot above base; regular parallel laminae. Sample no. 1669 at 1 foot above base.	3	163-1/2
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b) in part with scattered and clustered 1/2-mm. crystals of sparry carbonate; scattered bioclastics including numerous small gastropods; very irregular bands, laminae and streaks weathering yellowish gray (5Y8/1). Sample no. 1668 at top.	2-1/2	160-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4), parting into 1/2- to 2-foot layers; unit consists of several repetitions of following lithologies: 4-inch to 6-inch zone of pebble calcarenite (B-5) at base of each cycle grading upward into cryptogranular limestone (B-4c) with calcarenite lenses and with thin streaks and laminae weathering		

	Thickness (feet) unit	total
dark yellowish brown (10YR4/2) to black (N1), becoming 1/4-inch to 1/2-inch thick in upper portions of each cycle; zone of dark gray (N3) chert nodules and cherty mottling 5 feet below top of unit. Samples no. 1667 from calcarenite; no. 1665 and no. 1666 from dolomitic laminated zones.	12	158
Dolomite, medium gray (N5), finely megacrystalline (B-1b), parting into 1-1/2 foot layers; 1-inch to 2-inch bands of regular parallel laminae. Sample no. 1664 at 1-1/2 feet above base.	3	146
Dolomite, medium gray (N5), very finely megacrystalline (B-1b to B-1h); regular parallel laminae; weathered surface yellowish gray (5Y8/1) with pitting caused by selective solution of 1/2-mm. to 2-mm. grains of calcite sand. Sample no. 1663 at 2 feet above base.	4	143
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4c) with disseminated crystals of sparry carbonate and scattered bioclastics; upper 2-1/2 feet contains yellowish-gray (5Y8/1)-weathering laminae and streaks grading into calcareous-laminated dolomite (B-1b) at top of unit. Samples no. 1662 at top; no. 1661 at 6 inches above base.	3	139
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b) with scattered 1-mm. crystals of sparry carbonate, parting into 2-foot layers; 2 feet at base of very irregular streaks and elongate lobes and lenses of dolomite grading upward into 2 feet of 1/8-inch to 1/4-inch, wavy to subreticulate laminae. Sample no. 1660 at top; no. 1659 at base.	4	136
Limestone, medium gray (N5), roughly fracturing cryptogranular (B-4d); irregular, wavy to subreticulate 1/4-inch to 1-inch, medium-		

	Thickness (feet) unit	total
dark-gray (N4), siliceous bands grading into overlying unit; 1 foot of siliceous banded pebble calcarenite (B-5) at base. Samples no. 1658 at top; no. 1657 at base.	3-1/2	132
Dolomite, medium gray (N5), finely megacrystalline (B-1a), parting 1 foot above base. Sample no. 1606 at 1 foot above base.	2-1/2	128-1/2
Limestone, parting into 5-foot layers; predominant lithology is medium gray (N5), roughly- to smoothly fracturing cryptogranular limestone (B-3a) with anastomosing to subreticulate, 1/4-inch to 2-inch, medium-dark-gray (N4), siliceous bands weathering into prominant relief; several 1-foot zones of medium to coarse bioclastic pebble calcarenite (B-5b) with patchy development of interclastic dolomite concentrated in 1/4-inch laminae; calcarenite has 1/4-inch discontinuous silty-dolomitic laminae; well developed closely spaced rock cleavage along which movement has distorted the sedimentary structures. Samples no. 1655 at 18 feet; no. 1654 at 14 feet; no. 1653 at 12 feet; no. 1652 at 6 feet above base.	25	126
Limestone, medium gray (N5) to medium light gray (N6), roughly fracturing cryptogranular (B-4b); 6-inch zone of dolomitic mottling in center. Sample 1551 at 3 feet above base.	6	101
Dolomite, medium gray (N5) to medium light gray (N6), finely megacrystalline (B-1b); regular parallel laminae. Sample no. 1650 at 2 feet above base.	5	95
Following exposures described in small quarry higher on river bank. No samples taken. Possible discrepency in measurement here of 5 to 10 feet.		

	Thickness (feet) unit	total
Dolomite, medium light gray (N6), very finely megacrystalline, (B-1b), weathering yellowish gray (5Y8/1), parting into 2-foot layers; regular parallel laminae. Estimated thickness.	15	90
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b) in part; zones of dolomite mottling; grades downward through 5 feet of dolomite bands into underlying unit. Estimated thickness.	15	75
Dolomite, medium gray (N5), finely megacrystalline (B-1b), parting into 1-foot layers; regular parallel laminae. Estimated thickness.	12	60
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3).	3	48
Concealed; dolomite and limestone float on bank of river; traverse 55 feet about N75°W perpendicular to strike of bedding; bedding N13°E 62°NW. Beds partially exposed in section No. 9.	45	45
Thickness of Epler Formation		798-1/2

Rickenbach Dolomite

Upper member. Type section 233

SECTION NUMBER 5

Rickenbach, Pennsylvania (N0. 2) Date described: July, 1954

Location and structure of section

Section No. 5 is in abandoned quarry now used as refuse dump in the town of Rickenbach, Berks County, Pennsylvania, in northwest part of Reading quadrangle, approximately 0.60 miles north of 40° 25' latitude and 2.25 miles west of 76° 55' longitude (Fig. 3).

Beds strike N25°E and dip 65°NW. Cleavage poorly developed in some beds and dipping steeply southeast.

Measurements made with 8-foot tape perpendicular to bedding. Thickness for uppermost dolomite portion estimated from data in Gray (1951, p. 31).

Section description	Thickness (feet) unit	total
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Lower member		
Dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline, parting in 2- to 3-foot layers, weathering yellowish gray (5Y8/1); regular parallel laminae in some beds; several scattered dark-gray chert nodules and stringers.	50	50
Estimated exposure of lower member		50
Epler Formation		
Limestone, medium gray (N5), roughly fracturing cryptogranular, weathering light gray (N7), parting into 1/2- to 8-foot layers; bioclastic pebble calcarenite lenses scattered throughout; zones of black-weathering, anastomosing, siliceous laminae and "fucoidal" dolomite mottling weathering yellowish gray (5Y8/1).	15	116
Dolomite, medium gray (N5), very finely mega-		

	Thickness (feet) unit	total
crystalline; numerous pits and patches of calcitic material grading downward with increasing proportion into a 5-inch basal limey zone containing dolomite pebbles in limestone matrix.	3-1/2	101
Limestone, medium gray (N5), roughly fracturing cryptogranular with scattered sparry calcite crystals; lenses of pebble calcarenite; zones of black-weathering siliceous laminae and "fucoidal" dolomitic mottling.	9-1/2	97-1/2
Dolomite, moderately effervescent, medium gray (N5), very finely megacrystalline, laminated.	1/2	88
Limestone, medium gray (N5), roughly fracturing cryptogranular; irregular, anastomosing, black-weathering siliceous laminae.	5-1/2	87-1/2
Dolomite, moderately effervescent, medium gray (N5), very finely megacrystalline, parting into 1/2- to 3-foot layers; regular parallel laminae with polygonal mudcracking on bedding surface.	4-1/2	82
Limestone, medium gray (N5), parting into irregular 1-foot layers; fine to medium calcarenite with 1/2-inch-long, subrounded pebbles; several dolomitized, apparently low-spired gastropods.	9	77-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular; lenses and thin irregular beds of pebble calcarenite.	3-1/2	68-1/2
Dolomite, medium gray (N5), finely megacrystalline, weathering yellowish gray (5Y8/1), parting 4 feet above base; regular parallel laminae; styolites.	5	65
Limestone, medium gray (N5), roughly fracturing cryptogranular, parting into 2-1/2-foot		

	Thickness (feet) unit	total
layers; black-weathering, anastomosing, siliceous, laminae; several calcarenite lenses in upper 2-1/2 feet.	7	60
Dolomite, medium gray (N5), finely to medium megacrystalline, weathering yellowish gray (5Y8/1); lower 1 foot of regular parallel laminae with marked effervescence.	2-1/2	53
Limestone, medium gray (N5); bioclastic medium calcarenite; black, siliceous streaks in upper 1 foot.	4-1/2	50-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular; scattered lenses of pebble calcarenite; black-weathering irregular laminae and streaks; fucoidal dolomitic mottling in lower 1-1/2 feet.	10	46-1/2
Dolomite, medium gray (N5), finely megacrystalline, weathering light gray (N7).	3	36-1/2
Limestone, medium gray (N5), parting into 1- to 2-foot layers; beds and lenses of bioclastic pebble calcarenite alternating with zones of black-weathering, siliceous laminae and streaks.	6-1/2	33-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); indistinct laminae at top.	2-1/2	27
Limestone, medium gray (N5), roughly fracturing cryptogranular, parting into 1- to 3-foot layers; large proportion of bioclastic pebble calcarenite in lenses and irregular beds; zones of black-weathering siliceous laminae and streaks especially prominent near base; several zones of "fucoidal" dolomitic mottling; prominent mudcracked bedding plane at base.	24-1/2	24-1/2
Total exposed thickness Epler Formation		166

SECTION NUMBER 6

Leesport, Pennsylvania (No. 1) — Date described: July, 1956; Date sampled: August, 1956

Location and structure of section

Type section of Ontelaunee Formation is located along east bank of Schuylkill River one mile southeast of Leesport, Berks County, Pennsylvania. Exposures are in southwest part of Reading quadrangle at approximately 1.20 miles north of 40° 25' latitude and 2.20 miles west of 75° 55' longitude, in Ontelaunee township (Fig. 3).

Eight readings indicate beds strike N25°W and dip 30°SW. Youngest beds exposed near trough of syncline and exposures continue northwest across limb of fold to crest of adjacent anticline. Thin limestones interbedded with dolomite display closely spaced, discontinuous bedding cleavage and distorted sedimentary structures. Distortion of primary structures is attributed to tectonic flowage paralleling cleavage. Poles of 36 joint surfaces were plotted on a Schmidt net. Although there is no well defined group of points, majority of surfaces strike northeast and dip steeply southeast or northwest. Two prominent northeast striking joints are visible on bedding surfaces. The most conspicuous surfaces strike about N20°E; the others strike about N60°E. A set with strikes generally paralleling strike of bedding dips northeast with angles varying around 60°. No southwest dipping joints were recorded.

Measurements made by traverse with 100 foot tape beginning with uppermost exposure at bend in stream. Traverse continues stratigraphically downward through chert beds in upper portion of lower member. Traverse distance to base of each unit is given in parentheses at end of each unit description.

Traverse N 9°E,	0-	369-1/2 feet,	bedding N25°W, 24°SW;
traverse N 5°E,	369-1/2-	414 feet,	bedding N14°W, 28°SW;
traverse N12°E,	414-	462 feet,	bedding N 5°W, 33°SW;
traverse N12°E,	607-1/2-	680 feet,	bedding N26°W, 31°SW;
traverse N17°E,	680-	714-1/2 feet,	bedding N47°W, 33°SW;
traverse N 3°E,	714-1/2-	757 feet,	bedding N47°W, 33°SW;
traverse N14°E,	757-	892 feet,	bedding N20°W, 31°SW;
traverse N14°E,	892-	936 feet,	bedding N26°W, 33°SW;
traverse N14°E,	936-	938 feet,	bedding N20°W, 31°SW;
traverse N 4°E,	938-	949 feet,	bedding N20°W, 31°SW;
traverse N 4°E,	949-	1030-1/2 feet,	bedding N33°W, 30°SW;
traverse N 3°E,	1030-1/2-	1130 feet,	bedding N33°W, 30°SW.

Samples located at stratigraphic distance above each descriptive unit.

Section description	Thickness (feet) unit	total
Lower Ordovician Series Beekmantown Group Ontelaunee Formation Upper member		
Dolomite, medium gray (N5), very finely megacrystalline (B-1a and B-1b), weathering yellowish gray (5Y8/1), parting into 1- to 3-foot layers; zones of indistinct laminae. Samples no. 1758 at base; no. 1759 at 13-1/2 feet; no. 1760 at 21 feet above base. (112 feet).	25	99
Concealed. (165 feet).	12	74
Dolomite and limestone, partially concealed; dolomite medium gray (N5), very finely megacrystalline (B-1b), parting into 1- to 3-foot layers; indistinct laminae; 1-foot beds of medium-gray, smoothly fracturing cryptogranular limestone (B-3b) with lobes and fucoidal-like cylindrical structures of dolomite weathering yellowish gray (5Y8/1); limestone beds at 1/2, 18, 26 and 31 stratigraphic feet above base of unit. Samples no. 1752 at 13 feet; no. 1753 at 15-1/2 feet; no. 1754 at 28 feet; no. 1755 at 28-1/2 feet; no. 1756 at 31 feet; no. 1757 at 43 feet above base. (369-1/2 feet).	47	62
Exposures; limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b); lobes and cylindrical masses of dolomite weathering yellowish gray (5Y8/1). Sample no. 1751 at top. (398 feet).	5	15
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 3/4-foot layers; indistinct laminae; development of branching cylindrical masses at contact with overlying unit. Sample no. 1750 at base. (412 feet).	1-1/2	10

	Thickness (feet) unit	total
Limestone, medium gray (N5), finely megacrystalline (B-3a); numerous very finely megacrystalline, medium-light-gray (N6) fucoidal structures. Sample no. 1749. (414 feet).	1/2	8-1/
Dolomite, medium gray (N5), very finely megacrystalline with finely megacrystalline patches (B-1b), parting into 3/4-foot layers; indistinct laminae; transitional with overlying unit through zone of fucoidal mottling (B-1d). Samples no. 1748 at top; no. 1747 at 1 foot above base. (429 feet).	2-1/2	8
Dolomite, medium light gray (N6), very finely megacrystalline (B-1a), parting into 1-foot layers; several medium-megacrystalline (B-2?) zones with indistinct laminae. Sample no. 1746 at 2 feet above base. (444 feet).	2-1/2	5-1/2
Exposures; limestone, medium light gray (N6), smoothly fracturing cryptogranular (B-3b); scattered fucoidal intergrowths weathering yellowish gray (5Y8/1). Sample no. 1745. (462 feet).	3	3
Exposed thickness of upper member.		99
Middle member		
Dolomite, medium gray (N5), finely megacrystalline (B-1b), parting into 1-foot layers; indistinct laminae. No sample. (480 feet).	11	165
Dolomite, medium light gray (N6), medium megacrystalline (B-2?), weathering yellowish gray. Sample no. 1744 at base. (491 feet).	4	154-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 2-foot layers; indistinct laminae. No sample. (519 feet).	5-1/2	150
Dolomite, medium light gray (N6) with medium-dark-gray (N4) siliceous patches, very finely		

	Thickness (feet) unit	total
megacrystalline (B-1f), weathering with rough knobby surface. Sample no. 1743 at 1-1/2 feet above base. (528 feet).	3	144-1/2
Dolomite, medium gray (N5), microcrystalline (B-1b); indistinct laminae. Sample no. 1742 at 1 foot above base. (534-1/2 feet).	2-1/2	141-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b) with 1/2-inch microcrystalline laminae, parting into 1-1/2- to 2-foot layers. Sample no. 1741 at 3-1/2 feet above base. (564-1/2 feet).	9-1/2	139
Exposures; dolomite, medium light gray (N6) with medium- gray (N5) streaks and splotches, very finely megacrystalline (B-1), weathering yellowish gray (5Y8/1); scattered, irregular, micro-fractures filled with white dolomite. No sample. (587-1/2 feet).	7-1/2	129-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1a). Sample no. 1740 at 1 foot above base. (592-1/2 feet).	1-1/2	122
Dolomite, medium gray (N5), finely megacrystalline (B-1b), laminated. Sample no. 1739 at top. (602-1/2 feet).	3	120-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1a); scattered nodules of dark-gray (N3) chert. No sample. (607-1/2 feet).	1-1/2	117-1/2
Dolomite, medium gray (N5), finely megacrystalline (B-1a). No sample. (622-1/2 feet).	5	116
Dolomite, medium gray (N5), medium megacrystalline (B-2); indistinct, medium-dark-gray (N4) stringers and irregular, wavy laminae. Sample no. 1738. (630-1/2 feet).	3	111
Dolomite, medium light gray (N6), very finely		

	Thickness (feet) unit	total
megacrystalline (B-1b), parting into 1-1/2-foot layers weathering yellowish gray (5Y8/1); medium-megacrystalline (B-2) zones; wavy laminae and bands at top. Samples no. 1736 at 1/2 foot above base; no. 1737 at top. (638-1/2 feet).	3	108
Dolomite, medium dark gray (N4), very finely megacrystalline (B-1a). Sample no. 1735 at base. (646-1/2 feet).	3	105
Dolomite, medium gray (N5) with regular medium dark gray (N4) laminae, very finely megacrystalline (B-1a), weathering yellowish gray (5Y8/1), parting into 1-foot layers. Sample no. 1734 at 9 feet above base. (680 feet).	12	102
Dolomite, medium gray (N5), very finely megacrystalline (B-1a). No sample. (685 feet).	2-1/2	90
Dolomite, medium gray (N5), finely megacrystalline (B-1a), parting into 1-foot layers; scattered 1-inch to 2-inch nodules of black (N1) chert. Sample no. 1733. (698-1/2 feet).	7	87-1/
Dolomite, medium dark gray (N4), finely megacrystalline (B-2?); 1-inch to 2-inch, irregular nodules and patches of dark-gray (N3) chert; disseminated irregular micro-fractures filled with white dolomite; rough, knobby weathered surface. Sample no. 1732 at base. (706-1/2 feet).	3	80-1/
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 1-foot layers; regular laminae. Sample no. 1731 at top. (714-1/2 feet).	3-1/2	77-1/
Dolomite, moderately effervescent in laminated zones, medium light gray (N6), very finely megacrystalline (B-1b), parting into 1-foot layers; distinct, regular laminae at base. Samples no. 1730 at 1/2-foot above		

	Thickness (feet) unit	total
base; no. 1729 at top. (751-1/2 feet).	9-1/2	74
Dolomite, medium gray (N5) with medium-dark-gray (N4) splotches, finely megacrystalline (B-1e to B-1f), parting into 1-foot layers; scattered nodules of dark-gray (N3) chert; medium-dark-gray splotches weather into low relief. Sample no. 1728 at base. (757 feet).	2-1/2	64-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 1- to 2-foot layers; indistinct laminae. Sample no. 1727 at 2 feet above base. (854 feet).	34	62
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b), parting into 1-foot layers; indistinct laminae. Sample no. 1726 at top. (865-1/2 feet).	4	28
Dolomite, medium gray (N5), finely megacrystalline (B-1b); indistinct laminae. Sample no. 1725 at base. (870 feet).	1-1/2	24
Dolomite, medium light gray (N6), finely megacrystalline (B-1a), weathering yellowish gray (5Y8/1). Sample no. 1724 at 1 foot above base. (877 feet).	2-1/2	22-1/2
Dolomite, medium gray (N5), finely megacrystalline (B-1b); indistinct laminae. Sample no. 1723 at top. (880 feet).	1	20
Dolomite, mottled medium gray (N5) and medium light gray (N6), very finely megacrystalline (B-1e), parting into 1- to 1-1/2-foot layers; indistinct laminae. Sample no. 1722 at base. (892 feet).	4	19
Dolomite, medium gray (N5), very finely megacrystalline (B-1a to B-1f); zone several feet above base of medium-dark-gray (N4), irregular siliceous lenses and stringers weathering into low relief. Samples no. 1721 at top; no. 1720		

	Thickness (feet) unit	total
at 9-1/2 feet; no. 1719 at 5 feet; no. 1718 at 1 foot above base. (936 feet).	15	15
Thickness of middle member		165
Lower member		
Chert layer (B-7), dark gray (N3), weathering with dolomoldic-pitted and vuggy surface. Sample no. 1717.	1/2	56-1/2
Dolomite (no parting recorded), medium gray (N5), medium megacrystalline (B-2c); siliceous stringers weather into low relief. Sample no. 1716. (938 feet, including chert layer).	1/2	56
Dolomite, medium gray (N5), finely megacrystalline (B-1b); indistinct medium-dark-gray (N4) laminae. Sample no. 1715. (949 feet).	2	55-1/2
Dolomite, medium gray (N5), medium megacrystalline (B-2); interbedded angular, and rounded fragments of dark-gray chert. Sample no. 1714. (950-1/2 feet).	1/2	53-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1), parting into 6-inch layers; small, irregular patches of medium-gray (N5), medium-megacrystalline (B-2) dolomite. Sample no. 1713 at 1 foot above base. (958-1/2 feet).	2-1/2	53
Dolomite, medium gray (N5), fine to medium megacrystalline (B-2), parting into 6-inch layers; zones of indistinct laminae. Sample no. 1712 at base. (973-1/2 feet).	4-1/2	50-1/2
Dolomite, slowly effervescent, medium gray (N5), medium megacrystalline (B-2 and B-2c); 1/8-inch to 1-inch bands of dark-gray (N3) chert; 3 inches of dark-gray cherty mottling at top. Samples no. 1710 at 2-1/2 feet above base; no. 1711 at top. (983-1/2 feet).	3	46

	Thickness (feet) unit	total
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b); indistinct medium-gray (N5) laminae. Sample no. 179 at top. (996-1/2 feet).	4	43
Dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline (B-1b); zones of microcrystalline dolomite; indistinctly laminated and weathering yellowish gray (5Y8/1). Sample no. 178 at top. (1010-1/2 feet).	4	39
Dolomite, medium gray (N5), finely megacrystalline (B-1); regular crinkly to wavy, dark-gray (N3) laminae. Sample no. 177 at top. (1014-1/2 feet).	1	35
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), weathering yellowish gray (5Y8/1); thin bands of indistinct laminae. Sample no. 176 at top. (1030-1/2 feet).	5	34
Dolomite, medium light gray (N6) with medium-dark-gray (N5) splotches in some beds, finely megacrystalline (B-1 to B-2), weathering yellowish gray (5Y8/1), parting into 1/2- to 1-foot layers; indistinct laminae; vugs filled with white sparry dolomite. Sample no. 175 at top. (1078-1/2 feet).	14	29
Exposures; dolomite, medium gray (N5) with irregular medium-dark-gray (N4) stringers and lenses, very finely megacrystalline (B-1), parting into 1-foot layers; several slowly effervescent medium-megacrystalline (B-2) beds that are mostly associated with chert and occur toward top of unit; unit contains several 1- to 1-1/2-foot beds of dark-gray (N3) chert (B-7) and 1/4-inch to 1-foot long, angular blocks of chert imbedded in dolomite; beds of chert contain several interbedded angular dolomite fragments. Chert in form of rounded "heads" resembling "cauli-		

	Thickness (feet) unit	total
flower" chert in some bedding planes. Samples no. 173 at top; no. 172 at about 7 feet; no. 171 at about 5 feet above base. (1130 feet).	15	15
Exposed thickness of lower member		56-1/
Exposed thickness of Ontelaunee Formation		320-1/

SECTION NUMBER 7

Reading Boat Club,
Tuckerton, Pennsylvania

Date described: July, 1956

Location and structure of section

Section No. 7 is exposed 1-1/2 miles west of Tuckerton, Berks County, Pennsylvania, in west central part of Reading quadrangle at approximately 0.45 miles south of 40° 25' latitude and 1.80 miles east of 76° 00' longitude (Fig. 3). The beds are in the southwest bank of the Schuylkill River immediately southeast of and upstream from the docks of the Reading Boat Club.

Beds are on normal northwest limb of anticline. Bedding strikes N10°E and dips 65°NW. Measurements made perpendicular to bedding with 8-foot tape.

Section description	Thickness (feet) unit	total
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Middle member		
Exposures; dolomite, medium gray (N5), very finely megacrystalline (B-1a), parting into 1/2- to 1-foot layers.	5	23-1/2
Dolomite, parting into 1/2- to 2-foot layers; medium-gray (N5) and medium-light-gray (N6) mottling and laminae; very finely megacrystalline (B-1e); lower 2 feet with indistinct breccia of angular dolomite fragments.	12	18-1/2
Dolomite, medium gray (N5), medium megacrystalline (B-2c); subreticulate distribution of dark-gray (N3) chert weathering into relief.	1-1/2	6-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1); several scattered, subnodular masses of dark-gray (N3) chert.	4	5
Dolomite, medium light gray (N6); angular dolo-		

	Thickness (feet) unit	total
mite fragments in finely megacrystalline matrix; welded contact with underlying unit.	1	1
Exposed thickness of middle member		23-1/
Lower member		
Chert layer (B-7), dark gray (N3).	1	204-1/
Dolomite, medium gray (N5), medium megacrystalline (B-2); welded contact with underlying chert.	1	203-1/
Chert layer, (B-7), dark gray (N3).	1	202-1/
Dolomite, medium gray (N5), medium megacrystalline (B-2); angular fragments of dolomite; welded contact with underlying chert.	1-1/2	201-1/
Chert (B-7), evenly bedded at base, irregular to nodular at top, dark gray (N3).	1	200
Dolomite, medium gray (N5), medium megacrystalline (B-2), parting into 1-foot layers; indistinct laminae; zone of chert nodules in center; small white chert rosettes at base.	2	199
Dolomite, medium gray (N5), very finely megacrystalline (B-1b); indistinct laminae.	1-1/2	197
Dolomite, medium dark gray (N4), medium megacrystalline (B-2); zone of coalescing chert nodules at base.	1	195-1/2
Dolomite, medium gray (N5) to medium light gray (N6), parting into 1- to 2-foot layers; crystal size not recorded; laminae at base; thin discontinuous beds and nodules of chert in lower half.	13	194-1/2
Dolomite, medium gray (N5), finely megacrystalline (B-1f); subreticulate, medium-dark-gray, cherty mottling in center grading laterally into discontinuous bed of chert (B-7).	5	181-1/2

	Thickness (feet) unit	total
Dolomite, medium gray (N5), very finely megacrystalline (B-1b); indistinct laminae.	1	176-1/2
Dolomite, medium gray (N5), finely megacrystalline (B-1); scattered chert rosettes and nodules; welded contact with underlying chert.	2-1/2	175-1/2
Chert layer (B-7), dark gray (N3).	1/2	173
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b); laminae.	1	172-1/2
Dolomite, medium gray (N5), finely megacrystalline (B-1); scattered sub-nodular masses of chert.	3	171-1/2
Chert layer (B-7), dark gray (N3).	1-1/2	168-1/2
Dolomite, medium gray (N5), very finely megacrystalline (B-2b), parting into 1/2- to 2-foot layers; indistinct laminae.	9	167
Chert layer (B-7), dark gray (N3).	1	158
Dolomite, medium gray (N5), finely megacrystalline (B-1).	10	157
Dolomite, medium light gray (N6), very finely megacrystalline (B-1b), parting into 1-foot layers; regular parallel laminae.	4	147
Concealed.	11-1/2	143
Chert layer (B-7), dark gray (N3).	1	131-1/2
Exposures; dolomite, medium light gray (N6), very finely megacrystalline (B-1b); laminae.	11-1/2	130-1/2
Dolomite, medium dark gray (N4), finely megacrystalline (B-2?), irregular micro-fractures filled with white dolomite.	2	119
Dolomite, medium light gray (N6), very finely		

	Thickness (fee	
	unit	tota
megacrystalline (B-lb); laminae; 2-inch to 4-inch bed of dark-gray (N3) chert 6 inches from top.	4	11
Dolomite, medium gray (N5), finely megacrystalline (B-lf), subreticulate cherty mottling at base.	6	11
Dolomite, medium light gray (N6), very finely megacrystalline (B-lb), parting into 1/2- to 1-foot layers; weathering yellowish gray (5Y8/1), regular parallel laminae.	14	10
Exposures; dolomite, medium gray (N5), very finely megacrystalline with finely-megacrystalline interbeds (B-lb), indistinctly laminated in most exposed beds.	57	9
Dolomite, medium gray (N5), finely megacrystalline with brecciated beds containing angular dolomite fragments.	6	3
Concealed. Dolomite float.	30	3
Exposed thickness of lower member		204-1/
Exposed thickness of Ontelaunee Formation		22
Epler Formation		
Interbedded dolomitic calcarenite and very-finely-megacrystalline dolomite at top. Incomplete exposures of entire formation.	750-850	

SECTION NUMBER 8

;toudt's Bridge, Date described: July, 1955
Reading Quadrangle, Pennsylvania

ocation and structure of section

Section No. 8 is exposed along west bank of Schuylkill River in old iver side quarry adjacent to foundation of former Stoudt's Bridge, 2 niles due south of West Leesport, Berks County, Pennsylvania, in west entral part of Reading quadrangle approximately 0.43 miles south of 0° 25' latitude and 1.55 miles east of 76° 00' longitude (Fig. 3).

Section is on normal northwest limb of anticline. Beds strike J10°E and dip 60°NW. Float apparently from Martinsburg and Jackson- urg formations is plentiful at top of bank, about 25 to 50 stratigraphic eet above uppermost dolomite bed. Approximately 250 to 300 apparent tratigraphic feet of concealed strata calculated from aerial photo neasurement separate lowest bed in section from uppermost chert exposed long opposite bank of river (section No. 7). Measurements taken per- endicular to bedding with 8-foot tape.

ection description	Thickness (feet) unit	total
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Upper member		
Dolomite, medium gray (N5), very finely mega- crystalline (B-1a to B-1b), parting into 1- to 3-foot layers; upper 18 feet contains zones of regular parallel laminae.	39-1/2	118-1/2
Dolomite, medium dark gray (N4) to dark gray (N3), very finely megacrystalline (B-1a), weathering light gray (N7).	2-1/2	79
Dolomite, medium gray (N5), very finely mega- crystalline (B-1b), parting into 1- to 2- foot layers; indistinct, regular, parallel laminae.	4	76-1/2
Dolomite, medium light gray (N6), very finely megacrystalline (B-1a), parting into 2- to 3- foot layers.	9-1/2	72-1/2

	Thickness (fee unit	tot
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 1/2- to 3-foot layers; indistinct laminae.	16-1/2	6
Dolomite, medium light gray (N6), microcrystalline (B-1b), parting into 1- to 3-foot layers; indistinct laminae; weathering yellowish gray (5Y8/1).	5	46-1
Dolomite, medium gray (N5), finely megacrystalline (B-1b), parting into 1-foot layers; regular parallel laminae.	9	41-1
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3b), weathering very light gray (N8); streaks and thin irregular stringers of dolomite weathering yellowish gray (5Y8/1).	5	32-1
Dolomite, medium gray (N5), very finely megacrystalline. (B-1a).	3-1/2	27-1
Limestone, medium gray (N5), smoothly fracturing cryptogranular (B-3a), gradational with adjacent units through zones of yellowish gray (5Y8/1)-weathering stringers and lenses weathering yellowish gray (5Y8/1).	1/2	2
Dolomite, medium gray (N5), very finely megacrystalline (B-1a).	3-1/2	23-1
Dolomite, medium gray (N5), very finely megacrystalline (B-1b), parting into 1- to 3-foot layers; indistinct laminae on weathered surface.	10	2
Dolomite, medium gray (N5) to medium light gray (N6), parting into 1- to 3-foot layers; 1-foot zone 4-1/2 feet above base of 1/2- to 1-foot, elongate to equant, subangular dolomite fragments in a very finely megacrystalline matrix.	10	1
Exposed thickness of upper member		118-1
Exposed thickness of Ontelaunee Formation		118-1

SECTION NUMBER 9

,eesport, Pennsylvania (No. 2)

Date described: July, 1955
Redescribed in part and revised: June, 1957

,ocation and structure of section

Uppermost part of composite section is located 0.75 miles south-ast of Leesport, Berks County, Pennsylvania, in northwestern part of .eading quadrangle about 2.15 miles east of 76° 00' longitude and 1.7 ıiles north of 40° 25' latitude (Fig. 3).

Section continues southward and stratigraphically downward from ›undation for railroad trestle, through Ontelaunee Formation along astern bank of Schuylkill River to horizon of chert nodules and "cauli-.ower" chert in axial part of anticline. This chert zone appears to be bout 60 to 65 feet stratigraphically above uppermost chert bed of the ›wer member of the Ontelaunee Dolomite as exposed in southeastern mb of adjacent syncline to the south. Section begins at uppermost hert bed and continues through railroad and river cuts across limb of yncline to exposures of Stonehenge lithology exposed in the east bank f the Schuylkill River north of the mouth of Maiden Creek.

Traverse data included in section descriptions. Section measure-ıents made perpendicular to bedding wherever possible.

ection description	Thickness (feet) unit	total
Middle Ordovician Series		
Jacksonburg Limestone		
Limestone, dark, argillaceous, with orange-weathering bands in lower part; two beds of moist, sticky, yellowish-weathering (bentonite) shale about 30 to 40 feet above base; well developed fracture cleavage N20°E, 90°; bedding in lower strata strikes N42°E, dips 45°NW; broad flexures exposed through section; probably less than 150 feet exposed.	Estimated -150	150
Estimated thickness of Jacksonburg Limestone		150

- probable unconformity -

,ower Ordovician Series
Ontelaunee Dolomite (exposures along river bank)
Upper and middle members

	Thickness (feet) unit	total
Concealed; traverse S35°E, 130 feet; bedding N38°E, 45°NW.	87-1/2	415
Dolomite, medium gray (N5), very finely megacrystalline and finely megacrystalline, weathering yellowish; thin interbeds of dolomitic-mottled; very finely megacrystalline to calcilutitic limestone with dolomitized high-spired gastropod resembling <u>Hormotoma</u> sp. and a nautiloid cephalopod resembling <u>Orthoceras</u> sp. Traverse S15°E, 70 feet; bedding N35°E, 45°NW.	31-1/2	327
Concealed; traverse S5°E, 50 feet; bedding N27°E, 37°NW. Small exposures of very-finely-megacrystalline, jointed dolomite in southern 20 feet of traverse.	16	295-1/
Concealed; traverse 480 feet, S20°E past house; bedding N15°E, 32° NW. Small outcrop of dolomite in southern portion of traverse.	144	279
Concealed; traverse S20°E, 75 feet, bedding N10°E, 35°NW. Contains small exposures of dolomite.	18-1/2	135-1/
Concealed; traverse S20°E, 345 feet, bedding as above; small outcrop of dolomite at southern end of traverse.	98-1/2	117
Concealed; traverse S10°E, 100 feet, bedding N7°E, 40°NW; to bed with abundant chert nodules and beads of "cauliflower" chert. Chert and dolomite extensively brecciated along bedding. About 15 to 25 feet exposed to axis of anticline. This chert zone appears to be equivalent to the cherty zone about 60 to 65 stratigraphic feet above the base of the lower member in section no. 6.	18-1/2	18-1/
Measured thickness of middle and upper members		415
Concealed to base of member (from measurement in section 6 in which interval is exposed).		60

	Thickness (feet) unit	total
Total thickness of middle and upper members		475
Lower member		
Exposures in bed of river; traverse about S70°E perpendicular to strike, 164 feet; bedding N20°E, 75°NW; chert beds at 0, 5, 60, 69, 79, 124, 162, and 164 stratigraphic feet below top. Chert beds interbedded with very-finely- to medium-megacrystalline dolomite exposed in bed of river.	160	257
Concealed; traverse perpendicular to strike of bedding, 100 feet to projection of strike of beds in railroad cut; bedding N30°E, 75°NW. Includes 23 feet of medium- to medium-light-gray, very-finely-megacrystalline, laminated dolomite at base.	97	97
Measured thickness of lower member		257
Measured thickness of Ontelaunee Formation (believed to be maximum value)		732
Epler Formation		
Concealed; traverse N20°W, 75 feet along railroad tracks, bedding N40°E, 75°NW; beds have been quarried at level of railroad tracks above river.	56	741-1/2
Interbedded limestone and dolomite; dolomite proportion increasing toward base. Upper limestones calcarenitic, lower limestones megacrystalline. Dolomites medium gray (N5), thinly-laminated, weathering yellowish. Section measured perpendicular to bedding.	493-1/2	685-1/2
- Fault, dipping 5° to 10° in a southerly direction; drag indicates reverse movement -		
Dolomite, medium gray (N5) to medium light gray (N6), very finely to finely megacrystalline, laminated, parting into 1- to 4-foot layers; chert nodules common; few thin limestone beds.	192	192

	Thickness (feet) unit	total
Measured thickness of Epler Formation		741-1/
Rickenbach dolomite (Following section in Rickenbach dolomite is generalized from notes; Figure 5 in the text shows section in detail.)		
Upper member		
Dolomite, medium gray (N6), very finely megacrystalline, laminated, weathering yellowish gray; dark chert nodules and beds common.	113	113
Measured thickness of upper member		113
Lower member (?)		
Dolomite, medium dark gray (N4), medium megacrystalline.	17	35
- Fault, dipping at low angle in a southerly direction -		
Dolomite, incompletely exposed, medium gray (N5), to medium dark gray (N6), finely to medium megacrystalline; zones of dark chert nodules and stringers in several beds; unit represents an interbedding of fine and coarse dolomite types; coarse dolomite laced with small irregular micro-fractures filled with sparry dolomite. Lower 100 stratigraphic feet concealed; (traverse 130 feet, N40°W; bedding N20°E, 60°NW).	340	34
Measured thickness of lower member (includes lower concealed contact)		35
Measured thickness of Rickenbach Dolomite		47
Stonehenge Formation (no evidence of upper member) Middle or lower member		
Limestone; poorly exposed of flat-pebble conglomerate with dolomitic and siliceous bands and interfragmental dolomitic mottling.	23	2

	Thickness (feet) unit	total
Exposed thickness of Stonehenge Limestone		23
Total measured thickness of Beekmantown Group		1966

Concealed; small exposures of dolomite; 600 feet traverse distance to first quartzose bed of Conococheague limestone south of the mouth of Maiden Creek.

SECTION NUMBER 10

Moselem Springs, Pennsylvania Date described: August, 1954

Location and structure of section

Section No. 10 is exposed in abandoned quarry and road cut 1.1 miles northwest of Moselem Springs, Berks County, Pennsylvania in north central part of Reading quadrangle about 0.10 mile south of 40° 30' latitude and 1.0 mile west of 76° 55' longitude.

Lowermost beds in quarry involved in folds recumbent to northwes Upper contact with Jacksonburg limestone may be faulted (Gray, 1951, p. 51) or disconformable (Prouty, 1959). Beds believed to be upright on basis of order of superposition. Dolomite strikes N5°E to N30°E and dips 40°NW to 45°NW. Jacksonburg limestone strikes N40°E to N45°E and dips 40°NW to 45°NW. Epler limestones show considerable evidence of flowage and recrystallization with development of crystalline texture, folded laminae, and discontinuous bedding cleavage.

Section description	Thickness (feet) unit	total
Middle Ordovician Series Jacksonburg Limestone		
Limestone, dark, argillaceous, shaly, poorly exposed.	not measured	
- fault or unconformity -		
Lower Ordovician Series Beekmantown Group Ontelaunee Formation (?) Lower member (?)		
Concealed. Estimated apparent thickness.	25-50	87
Dolomite, medium gray (N5) with some medium-light-gray (N6) beds, very finely megacrystalline, weathering yellowish gray, parting into 1/2- to 3-foot layers; several laminated zones; numerous nodules, stringers and discontinuous beds of dark-gray chert in uppermost 40 feet; several zones containing angular chert and dolomite fragments; 5-foot concealed		

	Thickness (feet) unit	total
interval 17 feet above base and numerous concealed zones in lowermost zone.	62	62
Total thickness of lower Ontelaunee Formation (?)		87
Epler Formation (?)		
Limestone, medium gray (N5), very finely to finely megacrystalline; yellowish-gray (5Y8/1)-weathering laminae and streaks.	1	73-1/2
Dolomite, medium gray (N5), very finely megacrystalline, parting into 2-foot layers.	14	72-1/2
Limestone, medium gray (N5), megacrystalline.	1	58-1/2
Dolomite, medium gray (N5), very finely megacrystalline.	2	57-1/2
Limestone, medium gray (N5), megacrystalline, siliceous-laminated to -streaked.	3	55-1/2
Dolomite, medium gray (N5), very finely megacrystalline.	2-1/2	52-1/2
Limestone, medium gray (N5), laminated to streaked in lower 2 feet; dolomitic mottled at top.	4	50
Interbedded limestone and dolomite in subequal amounts.	4	46
Limestone, medium gray (N5), finely megacrystalline; dolomitic laminae and lenses.	3	42
Dolomite, medium light gray (N6), very finely megacrystalline.	1-1/2	39
Limestone, dolomitic laminated.	3	37-1/2
Dolomite, medium gray (N5), very finely megacrystalline.	3	34-1/2

	Thickness (fee	
	unit	tota
Limestone, medium gray (N5), very finely megacrystalline, laminated.	2	31-1
Dolomite, medium gray (N5), very finely megacrystalline.	1-1/2	29-1
Limestone; alternating 4- to 6-inch zones of dolomitic mottling and laminae.	5-1/2	2
Limestone, medium gray (N5), megacrystalline laminated.	3-1/2	22-1
Dolomite, megacrystalline.	1-1/2	1
Limestone, laminated, boudinaged beds.	3	17-1
Dolomite.	1-1/2	14-1
Limestone, medium gray (N5), megacrystalline, dolomitic-laminated.	3	1
Dolomite, medium gray (N5), finely megacrystalline; irregular calcite filled veins and fractures.	1	1
Limestone, megacrystalline; dolomitic mottling.	3	9
Limestone, medium gray, fine to medium pelmatozoan calcarenite, parting 6 inches above base; black-weathering siliceous laminae.	4	6
Limestone, medium dark gray (N4), roughly-fracturing cryptogranular; dolomitic mottled zone at top; poorly-developed bedding cleavage.	2	2
Exposed thickness of Epler Formation (?)		72

SECTION NUMBER 11

Wyomissing, Pennsylvania	Date described: June, 1955 July, 1956 Date sampled: June, 1955

Location and structure of section

Uppermost exposure of this series of sections is located approximately 1/65 miles north of 40° 21' latitude and 1.9 miles west of 75° 55' longitude in west central part of Reading quadrangle, Pennsylvania. Beds are in cuts for the P and R (Reading Belt) railroad tracks approximately 0.25 mile south of the railroad overpass spanning Tulpehocken Creek. Lowermost exposures are 0.1 mile to west of railroad overpass in road cut through property of Textile Machine Works (See Fig. 3).

Martinsburg Shale-Ontelaunee Dolomite contact strikes N90°E and dips 65°S. Bedding in dolomite and foliation in shales apparently parallel the contact. Beds of Rickenbach Dolomite near overpass strike N50°E to N80°E and dip 30°SE to 45°SE. The lowermost exposures strike N45°E and dip 25°SE. Traces of rock cleavage plunge 55°SE to 60°SE.

Strata of upper Rickenbach lithology are missing, apparently hidden under a major fault along which the Epler Formation has moved northwestward against the coarser crystalline beds of the lower Rickenbach Dolomite. This zone of movement is marked by deeply weathered, shattered zones of dolomite with completely obscured bedding in some places. Partially exposed beds of Stonehenge Limestone southeast of the overpass have been complexly folded, apparently a continuation of the structure at Glenside, Pennsylvania (section no. 1).

Section description	Thickness (feet) unit	total
Middle Ordovician Series		
Martinsburg Shale		
Shale, dark, weathering brown; well developed bedding foliation; 15 to 20 feet of calcareous shale (or shaly limestone) in middle of expo-		

	Thickness (feet) unit	total
sure; thickness not measured; upper contact concealed but believed to be a fault or unconformity; lower contact with Beekmantown dolomite sharp and unwelded and interpreted as disconformity.		
- disconformity -		
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Lower member (?)		
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), laminated in part; zone of bedded and nodular dark-gray chert at base. Estimated thickness.	45	45
Estimated thickness of exposed lower member		45
Estimated thickness of exposed Ontelaunee Formation		45
Concealed. Traverse N15°W, 1500 feet; bedding N65°E, 40°SE. Apparent stratigraphic thickness between 900 and 1000 feet.		950
Epler Formation		
Interbedded cryptogranular and calcarenitic limestone, dolomitic limestone and very-finely-megacrystalline, laminated dolomite; several bioclastic beds with poorly preserved outlines of gastropods and partially silicified brachiopods, two partially silicified specimens resemble Finkelnburgia sp. Samples no. 141 (top) to no. 1434 (base). Measured perpendicular to bedding in quarry.	100	100
Exposed thickness of Epler Formation		100
- Fault; stratigraphic displacement about 400 feet. -		

	Thickness (feet) unit	total
Rickenbach Dolomite		
Dolomite, massive, medium gray (N5), medium megacrystalline, weathering light gray.	8	182
Concealed.	8	174
Dolomite, massive, medium gray (N5), finely megacrystalline.	10-1/2	166
Dolomite, medium gray (N5) to medium dark gray (N4), medium megacrystalline (B-2) weathering light gray with gritty surface, parting into 4- to 5-foot layers; irregular discontinuous light and dark bands at base; white chert nodules and rosettes 8 feet from top; very irregular micro-fractures filled with sparry dolomite; lower contact concealed. Samples no. 1248 at 1 foot; no. 1249 at 7 feet; no. 1250 at 19-1/2 feet; no. 1251 at 18-1/2 feet; no. 1252 at 28-1/2 feet above base of unit.	28-1/2	155-1/2
Limestone, medium gray (N5), cryptogranular with zones of fine to medium calcarenite; 1-foot zones of dolomitic mottling, several apparently low-spired gastropod sections; one nautiloid cephalopod resembling Orthoceras sp., lower contact gradational. Samples no. 1246 at 5 feet; no. 1247 at 7 feet above base.	7	127
Limestone, medium gray (N5), cryptogranular, irregular yellowish-gray-weathering dolomitic mottling. Sample no. 1245 at 1 foot above base.	3	120
Dolomite, medium gray (N5), medium megacrystalline, indistinctly laminated to -banded, weathering medium light gray (N6); disseminated, irregular micro-fractures filled with sparry dolomite; unit contains irregular splotches and clusters of more calcitic material weathering out leaving a pitted to "vuggy" appearance. Sample no. 1243 and no. 1244.	17-1/2	117

	Thickness (feet) unit	total
Dolomite, medium gray (N5), medium to coarsely megacrystalline; several laminated beds at top; zones of darker spots and rounded to angular "grains" in medium-light-gray (N6) ground mass. Samples no. 1235 at 4 feet; no. 1236 at 10 feet; no. 1237 at 11 feet; no. 1238 at 18 feet; no. 1239 at 30 feet; no. 1240 at 40 feet; no. 1241 at 45 feet above base of unit.	51	99-1/2
Dolomite, medium gray (N5), medium megacrystalline, weathering light gray (N7); separated into 1/2-inch to 1-inch irregular bands. Sample no. 1234.	4	48-1/2
Dolomite, medium gray (N5), medium to coarsely megacrystalline, indistinctly laminated, highly fractured and shattered.	9	44-1/2
Dolomite, medium gray (N5), medium megacrystalline, extensively fractured and crumbles easily in weathered zones, parting into 1-foot layers. Sample no. 1233.	6	35-1/2
Dolomite, medium light gray (N6), finely to medium megacrystalline; zone of dark gray chert nodules 10 feet from base, laminae above chert with medium gray (N5), coarsely megacrystalline horizon in upper 15 feet. Samples no. 1230 at 4 feet; no. 1231 at 8 feet; no. 1232 at 23 feet above base of unit.	29-1/2	29-1/2
Total measured thickness of Rickenbach Dolomite		182
Stonehenge Limestone		
Upper member		
Limestone, smoothly fracturing cryptogranular; irregular lenses of bioclastic pebble calcarenite; lobes, lenses and irregular patches of dolomite; fossil impressions resembling Nanorthis? sp., Finkelnburgia sp. and fragments of hystricurid trilobites. Samples no. 1215 (base) to no. 1219 and 1222 to 1229 (top). Estimated thickness.	60	60

	Thickness (feet) unit	total
Estimated thickness of upper member		60
Middle member		
Limestone, medium gray (N5), roughly fracturing cryptogranular, weathering light gray (N7), parting 2-1/2 feet above base; irregular 1/2- to 1-inch, very finely megacrystalline dolomite bands increase in proportion from base into dolomite bed in upper 1-1/2 feet, weathering pale yellow orange (10YR8/6). Sample no. 1214 at 1 foot above base.	4	61
Limestone, medium gray (N5), weathering medium light gray (N6), parting into discontinuous 1/2- to 2-foot layers; unit consists of repetitions of 2- to 3-component rock body cycles; typical cycle contains 2- to 6-inch layer of flat-pebble calcirudite (B-6b) at base overlain by thicker zones of smoothly-fracturing cryptogranular limestone (B-3d) with sandy lenses and with a subreticulate siliceous mottling weathering shiny black (N1); this zone commonly is gradational above into 4-inch to 1-1/2-foot zones of silty-laminated and cross-bedded calcisiltite with anastomosing 1/16- to 1/2-inch siliceous and dolomitic laminae weathering yellowish gray (5Y8/1) to shiny black (N1) (B-4a); silty, cross-bedded lithology commonly overlain abruptly by fragmental layers in which pebbles are composed largely of silty-laminated calcisiltite and show varying degrees of orientation and disposition in relation to bedding; most commonly pebbles lie with apparent long axes subparallel to bedding; less characteristically the long axes are parallel and imbricated in angles of 30° to 45° to bedding, direction of imbrication varies with different beds but commonly remains the same within a single bed.	45-1/2	57
Limestone, medium gray (N5), roughly fracturing cryptogranular, parting into 6-inch layers; 1/2-inch bands and lenses weathering pale yellow orange (10YR8/6).	11-1/2	11-1/2

	Thickness (feet) unit	total
Measured thickness of middle member		61
Lower member		
Dolomite, medium gray (N5) to medium dark gray (N4), very finely megacrystalline, parting into 1-foot layers; regular parallel laminae. Sample no. 124 at 6 inches above base.	7	122-1/2
Limestone, medium gray (N5), roughly-fracturing cryptogranular; 2-inch to 3-inch bands and laminae weathering pale yellowish orange (10YR8/6), parting into 2-foot layers; 1-1/2 foot bed of calcirudite in middle with smaller zones throughout. Sample no. 123 at 5 feet above base.	9-1/2	115-1/2
Dolomite, medium gray (N5), very finely megacrystalline, parting 1-1/2 feet above base; regular parallel laminae; weathering yellowish gray (5Y8/1). Sample no. 122 at 1-1/2 feet above base.	9-1/2	106
Limestone, medium gray (N5), roughly fracturing cryptogranular, parting into 1-foot layers in lower 6-1/2 feet; 1/2-inch microfolded bands weathering pale yellowish orange (10YR8/6); zones of chert nodules; 8-inch calcirudite bed 2 feet above base. Samples no. 121, no. 1220 and no. 1221.	13	96-1/2
Concealed. Traverse N56°E, 500 feet; bedding strikes N65°E and dips 30°SE.	40	83-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular (calcisiltite), 1-inch-banded by black-weathering, 1/8-inch, wavy laminations, parting into 1-inch to 4-foot layers; 3-inch to 1-foot zones of calcirudite ("edgewise" conglomerate); laminae become 1/8-inch to 1-inch, pale-yellowish-orange (10YR8/6)-weathering bands at base.		

	Thickness (feet) unit	total
Samples no. 131 at 17-1/2 feet; no. 132 at 17 feet; no. 133 at 11-1/2 feet; no. 134 at about 10-1/2 feet; no. 135 at 9-1/2 feet; no. 136 at 8-1/2 feet; no. 137 at 7-1/2 feet; no. 138 at 6-1/2 feet; no. 139 at 4 feet; no. 1310 at 0 feet above base.	19-1/2	43-1/2
Dolomite, medium gray (N5) to medium dark gray (N4), very finely megacrystalline, parting into 1- to 2-foot layers; regular parallel laminae; weathering yellowish gray (5Y8/1). Sample no. 1311 at 4 feet above base.	8	24
Limestone, medium dark gray (N4), roughly fracturing cryptogranular, laminated with shaly partings weathering light gray (N7); closely spaced cleavage. Sample no. 1312 at 2 feet above base.	8	16
Dolomite, medium gray (N5) to medium dark gray (N4), finely megacrystalline, laminated, weathering yellowish gray (5Y8/1), parting into 1- to 3-foot layers. Sample no. 1313.	8	8
Exposed thickness of lower member		122-1/2
Exposed thickness of Stonehenge Formation		243-1/2
Measured thickness of Beekmantown Group		1520-1/2
Concealed. Traverse N45°W, 1237 feet from lower Stonehenge dolomite to uppermost exposed stromatolites (cryptozoon type) of Conococheague limestone; bedding N70°E, 40°SE.	670-700	
Cambrian System		
Conococheague Formation		
Limestone and dolomite; numerous quartz sand beds, oolitic cherts, oolite and stromatolites, cryptozoon type.	280	

SECTION NUMBER 12

Cacoosing, Pennsylvania Date described: August, 1955

Location and structure of section

Lowermost exposures of composite section are in abandoned quarry on recreation grounds of Textile Machine Works immediately northwest of Cacoosing Creek and 3/4 mile west by northwest of Cacoosing, Pennsylvania, in Wernersville quadrangle approximately 0.75 mile west of 76° 00' longitude and 0.85 mile north of 40° 20' latitude. From quarry, exposures continue to southwest and stratigraphically upward through an area of concealment into lower member of Ontelaunee Formation exposed along the southeast bank of Cacoosing Creek.

Thickness of beds between Martinsburg shale and uppermost chert bed of Ontelaunee Formation is estimated from concealed interval at western borough limits of Sinking Spring, 1.8 miles southwest of quarry section. Here 75 feet of dolomite with interbedded chert is exposed immediately southwest of the point where Cacoosing Creek flows beneath U.S. Route 322. Martinsburg shale is exposed in cut immediately north of highway. Martinsburg and Ontelaunee beds strike N8°E and dip 45°SE overturned; contact may be faulted.

In the quarry, beds strike N50°W and dip 30°SW. Rock cleavage, very prominent in some beds, strikes N45°W to N60°N and dips 40°SW to 50°SW. The chert beds along Cacoosing Creek strike N25°W and dip 28°SW. Dip joints are conspicuous, no readings recorded.

The limestones in the quarry have been extensively recrystallized with consequent obliteration of sedimentary textures and fabrics.

Section description	Thickness (feet) unit	total
- Following section at west borough limits of Sinking Spring -		
Middle Ordovician Series		
Martinsburg Shale		
Shale, dark gray, weathering brown; bedding foliation well developed. Not measured.		
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		

	Thickness (feet) unit	total
Concealed, 500 feet paced distance about S82°E; strike of beds N80°E, dip 45°SE overturned; to uppermost chert bed exposed immediately south of Route 422 within west borough limits of Sinking Spring.	300	504
Following section at approximate top of chert member along Cacoosing Creek 1.8 miles to NE; possible error of about 100 feet. -		
Dolomite, medium light gray (N6), very finely megacrystalline, poorly exposed, parting into 1- to 2-foot layers. Estimated thickness.	20	204
Rubble covered slope; dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline to finely megacrystalline; large blocks of medium-dark-gray (N4) to dark-gray (N3) chert. Traverse N85°E, 325 feet; bedding N57°W, 30°SW.	100	184
Dolomite, medium gray (N5), finely megacrystalline, parting into 1-foot layers; several beds of medium- to dark-gray (N5 to N3), medium- to coarsely-megacrystalline dolomite; dark-gray (N3) chert nodules. Traverse N85°E, 135 feet; bedding N57°W, 30°SW.	50	84
Dolomite, medium gray (N5) with some medium-light-gray (N6) splotches, medium to coarsely megacrystalline; uppermost beds medium light gray with masses of dark-gray (N3) chert.	12	34
Concealed.	12	22
Dolomite, medium gray (N5) to medium dark gray (N4), very finely megacrystalline, parting into 1-foot layers.	10	10
Total thickness of Ontelaunee Formation		504

Epler Formation (top at uppermost limestone)

Limestone, medium gray (N5), smoothly-frac-

	Thickness (feet) unit	total
turing cryptogranular weathering light gray (N7).	3	529
Concealed; exposures of smoothly and roughly fracturing cryptogranular limestone.	15	526
Dolomite, medium light gray (N6), with medium-gray (N5) laminae, very finely megacrystalline, parting into 1-foot layers.	8	511
Chert layer, medium gray (N5) to dark gray (N3).	1	503
Concealed. Traverse N85°E, 80 feet; bedding N57°W, 30°SW.	25	502
Limestone, medium gray (N5), very finely megacrystalline, weathering light gray (N7).	3	477
Concealed.	10	474
Limestone, medium gray (N5), cryptogranular, parting into 2-foot layers; poorly preserved gastropods, several resembling Hormotoma sp.	5	464
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	4	459
Limestone, medium gray (N5), very finely megacrystalline, streaked to laminated.	6-1/2	455
Concealed. Traverse S40°W, 510 feet; bedding N50°W, 34°SW. Concealed strata apparently composed largely of upper member.	285	448-1/
Exposures; dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); interbedded medium-gray (N5), cryptogranular limestone with one poorly preserved gastropod and abundant dolomitic mottling.	4	163-1/
Concealed.	15	159-1/

	Thickness (feet) unit	total
Limestone, medium gray (N5), very finely megacrystalline ("sugary"), weathering light gray (N7); 1/8-inch to 1/4-inch, irregular microfolded laminae weathering yellowish orange (10YR8/6) to black (N1).	1	144-1/2
Concealed.	4-1/2	143-1/2
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1-foot layers; closely spaced intersecting joints giving beds a blocky appearance.	4	139
Limestone, medium gray (N5), very finely megacrystalline, parting into 1/2-foot, irregular layers; numerous 1/2-inch lenses of finely-megacrystalline dolomite; ring-like and cylindrical dolomite structures 1- to 3-mm. in diameter are common and resemble replaced pelmatozoan fragments.	9	135
Dolomite, moderately effervescent, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2-foot layers.	4-1/2	126
Limestone, medium gray (N5), cryptogranular; laminated to streaked; numerous, irregular dolomite lenses weathering yellowish gray (5Y8/1); limestone weathers light gray (N7).	4-1/2	121-1/2
Dolomite, moderately effervescent, medium gray (N5), very finely megacrystalline, parting into 1/2-foot layers.	1	117
Limestone, medium gray (N5), very finely megacrystalline, no visible partings; 1/4-inch, finely megacrystalline, yellowish-gray (5Y8/1)-weathering dolomite lenses; well developed rock cleavage, N50°W, 45°SW. Unit measured along extensive joint surface.	50	116
Dolomite, medium gray (N5), finely megacrys-		

	Thickness (feet) unit	total
talline, weathering yellowish gray (5Y8/1), parting into 1/2-foot layers; lower 6-inch layer calcareous; dolomite bioclastic calcarenite 1 foot from base.	3	66
Limestone, medium gray (N5), cryptogranular; 1/4-inch bands in upper 2 feet weathering yellow orange (10YR6/6); numerous 2-inch to 6-inch lenses of pebble calcarenite (coarsely megacrystalline); 1-foot zone in middle dolomitic-streaked to -laminated.	4	63
Limestone, medium gray (N5), cryptogranular; irregular patches and lenses of very finely megacrystalline dolomite weathering yellowish gray (5Y8/1) are common.	1	59
Dolomite, medium gray (N5), very finely megacrystalline; several 1-inch, very irregular limestone bands; shell fragments surrounded by dolomite.	1-1/2	58
Limestone, medium gray (N5), finely megacrystalline; 1/4-inch to 1/2-inch dolomite bands and lenses weathering yellowish gray (5Y8/1); several coarsely crystalline (crinoidal?) lenses.	1-1/2	56-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular; 1/4-inch, micro-folded and anastomosing siliceous laminae weathering black (N1).	1/2	55
Limestone, medium gray (N5), roughly fracturing cryptogranular; numerous streaks and laminae weathering yellowish brown (10YR5/2); coarsely megacrystalline (calcarenite?) lenses.	3	54-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular; 1/4-inch micro-folded, anastomosing siliceous laminae weathering black (N1).	1/2	51-1/2

	Thickness (feet) unit	total
Limestone, medium gray (N5), roughly fracturing cryptogranular; numerous dolomitic streaks and laminae weathering yellow orange (10YR6/6); coarsely crystalline (crinoidal?) lenses; several indistinct shelly bioclastics replaced by dolomite and silica.	1	51
Limestone, medium gray (N5), roughly fracturing cryptogranular; micro-folded and anastomosing siliceous laminae weathering black (N1).	1	50
Limestone; alternating 4-inch to 5-inch zones of cryptogranular limestone with micro-folded, black (N1)-weathering, 1/4-inch siliceous laminae, and of pebble calcarenite with 1-inch-long, rounded pebbles in coarsely-megacrystalline ground mass.	6	49
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); extensive carbonate filled fractures.	2-1/2	43
Limestone, medium gray (N5), roughly fracturing cryptogranular; in 2-inch, black (N1)-weathering, micro-folded bands; two 1-inch zones of calcarenite with probable bioclastics.	1-1/2	40-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular, streaked to laminated.	1-1/2	39
Limestone, medium gray (N5), roughly fracturing cryptogranular; 1/4-inch, micro-folded bands in center weathering black (N1); rest of unit dolomitic-streaked to -laminated.	2	37-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular; numerous dolomite lenses and 1/4-inch irregular laminae weathering yellowish gray (5Y8/1).	1	35-1/2
Dolomite, slowly effervescent, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1	34-1/2

	Thickness (feet) unit	total
Limestone, medium gray (N5), cryptogranular; dolomitic laminae weathering yellowish gray (5Y8/1) separate unit into bands; scattered dolomitic structures resembling pelmatozoan fragments.	1-1/2	33-1/
Limestone, medium gray (N5), medium megacrystalline (crinoidal?); dolomite bands and irregular splotches weathering yellowish gray (5Y8/1); some bioclastic pebble calcarenite; single dolomitized low-spired gastropod with three or four whorls.	1-1/2	32
Limestone, medium gray (N5), cryptogranular with scattered shells and pelmatozoan fragments and calcarenite lenses; 1-inch to 6-inch micro-folded dolomite bands in center.	1-1/2	30-1/
Limestone, medium gray (N5), calcarenite; very irregular 1/2-inch to 1/4-inch bands weathering yellowish gray (5Y8/1).	1-1/2	29
Limestone, medium gray (N5), very finely megacrystalline, upper 2-1/2-feet dolomitic-laminated to -streaked; lower 2 feet banded with 1/4-inch, black (N1)-weathering siliceous laminae; some silty cross-bedding.	11-1/2	27-1/2
Dolomite, slowly effervescent, medium gray (N5), very finely megacrystalline, parting into 1/2-foot layers.	2	16
Limestone, medium gray (N5), cryptogranular, dolomitic-laminated to -streaked.	4	14
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1/2-foot layers.	2	10
Limestone, medium gray (N5), cryptogranular, laminated to streaked.	8	8
Exposed thickness of Epler Formation		529

	Thickness (feet) unit	total
Concealed, 1000 feet map distance about N40°E; bedding strikes about N50°W, average dip of bedding about 25°SW; traverse close to and approximately parallel to axial trace of fold, exposures at north end of traverse contain bioclastic pebble calcarenite with abundant low-spired dolomitized gastropods with three to five dextrally coiled whorls and abundant dark gray trilobite fragments.	420-420	
Total estimated thickness of Epler Formation	949	

- Fault -

Exposures, Ontelaunee Dolomite; abundant chert float.

SECTION NUMBER 13

Host, Pennsylvania   Date described: July, 1954

Location and structure of section

Section No. 13 is located in abandoned quarry in middle of cultivat field several hundred feet north of dirt road and about 600 feet west of co crete highway immediately northwest of Host, Berks County, Pennsylvania, in northwest part of Wernersville quadrangle at approximately 2.0 miles east of 76° 15' longitude and on 40° 25' latitude.

Strike in Beekmantown averages about N45°W and the dip average 50°SW. Contact with Martinsburg shale strikes N55°W and dips SW (Gray, 1951, p. 52). Contact truncates beds of limestone and is interpre ed as an unconformity. Lithology and proportion of limestone suggests that the section underlying the shales belongs to the upper Epler formatio

The limestones evidently have been recrystallized and largely lack sedimentary textures and structures.

Section description	Thickness (feet unit	total
Middle Ordovician Series		
Martinsburg Shale		
Shale, dark, weathering reddish brown, soft, fissile, phyllitic; bedding obscured; shale foliation truncates bedding in underlying carbonates.	25	25
- unconformity -		
Lower Ordovician Series		
Beekmantown Group		
Epler Formation		
Limestone, medium gray (N5), very finely megacrystalline with medium- to coarsely megacrystalline lenses (crinoidal?), parting into 1- to 3-foot layers; irregular streaks and lenses of yellowish-gray-weathering dolomite commonly comprising 40% to 50% of surface area; beds of dolomite (and calcitic-mottled dolomite) 1 foot and 9 feet above base of unit.	25-1/2	65-1/

	Thickness (feet) unit	total
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray.	1	40
Limestone, medium gray (N5), very finely megacrystalline, weathering with fluted surface along imperfect bedding cleavage, parting 12 feet above base; dolomitic streaks and lenses.	18	39
Dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline, weathering yellowish gray, (5Y8/1).	1	21
Limestone, medium light gray (N6), finely megacrystalline; black-weathering, anastomosing, siliceous streaks and laminae make up 60% of unit.	1/2	20
Dolomite, medium gray (N5), very finely megacrystalline.	1	19-1/2
Limestone, medium light gray (N6), finely megacrystalline; black-weathering siliceous laminae and streaks.	2	18-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1	16-1/2
Limestone, medium gray (N5), very finely megacrystalline with lenses of pelmatozoan calcarenite in lower 1-1/2 feet, parting into 1-foot layers; zones of black-weathering siliceous laminae and of dolomitic mottling.	5	15-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1/2	10-1/2
Limestone, medium gray, very finely megacrystalline with medium-megacrystalline lenses, containing dolomitized pelmatozoan stems, dolomitic-laminated to -streaked.	2	10
Dolomite, medium gray (N5), very finely megacrystalline.	2	8

	Thickness (feet) unit	total
Limestone, medium gray (N5), very finely mega-crystalline with lenses of indistinct calcarenite.	6	
Total measured thickness of Epler Formation.		65-1

SECTION NUMBER 14

Richland, Pennsylvania Date described: July, 1956

Location and structure of section

Lowermost beds (14a, Fig. 26) of composite section are approximately at 0.1 mile west of 76° 15' longitude and 0.8 mile north of 40° 20' latitude in the Lebanon quadrangle, Pennsylvania. About 1300 feet west of the lowermost exposures, which are exposed in a cut along the Reading Company's railroad tracks 1.1 miles east of the crossing at Richland, a small quarry (14b, Fig. 26) contains beds of Stonehenge limestone. Scattered exposures continue west of the quarry along the tracks for 925 feet. About 200 feet west of railroad crossing, beds of Rickenbach dolomite are exposed (14c, Fig. 26) and exposure continues westward and stratigraphically upward into middle part of Epler limestone and dolomite. Chert beds (14d, Fig. 26) are exposed along tracks 1-1/2 miles west of railroad crossing in Richland. As noted by Gray et al. (1954), beds of edgewise conglomerate bearing crinoids and of Stonehenge lithology are in contact with Conococheague limestone and dolomite in the lower part of the section. Outcrop of Annville limestone is (14e, Fig. 26) indicated on map by Gray (1952).

Bedding in quarry strikes N45°W and dips 20°SW. Immediately west of crossing and through major part of cut beds strike N15°E and dip 75° to 80°SE overturned. Lithologic succession, rock cleavage, and graded beds in zones of quartz sand indicate overturning. Flexures throughout the section result in variable dip and strike readings. At least one nearly recumbent fold is exposed and at several horizons the dolomites have been shattered sufficiently to obscure bedding relations. Almost without exception, limestones have undergone deformation along closely spaced planes of flow which parallel bedding in places. In several beds drag folding of laminae indicate an anamolous bedding and fold relation, i. e., tops to the east (Gray, et al., 1954). At the western end of the cut beds strike N20°E and dip 20°NW.

Fracture cleavage in dolomites strikes N50°E to N60°E and dips 28°SE to 68°SE (average 47°). Joints are numerous and well developed in dolomite beds west of crossing. Prominent dip joints strike about N75°W. Majority of dip joints dip 80°SW to 80°NE, a less conspicuous group dips 20° to 30°, largely to the SW. Oblique joints strike N60°E and dip 60°NW. Poorly developed strike joints strike N5°E to N10°E and dip 30°NW.

Measurements taken with 8-foot tape perpendicular to bedding in cuts and by pace and traverse over concealed intervals.

Section description	Thickness (feet) unit	total
Annville Limestone		
Float and small exposures of medium-light-gray (N6), very finely megacrystalline limestone.		
Concealed. Traverse about S70°E perpendicular to general strike of bedding, 1400 feet; dip of bedding 20°NW. Several exposures of megacrystalline limestone near south end of traverse.	475-500	
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Dolomite, medium gray (N5), very finely megacrystalline to finely megacrystalline, weathering very light gray (N8), parting into 2-foot layers; several concealed intervals with dolomite and black-chert float; black-chert nodules in upper 15 feet. Not included in measurements are exposures of very light gray, imperfectly cleaved limestones exposed along tracks to the west and included in concealed interval above. Traverse N60°W, 50 feet; bedding N7°E, 27°NW.	20-1/2	74-1
Concealed.	5	5
Limestone, light gray (N7), very finely megacrystalline, laminated; discontinuous bedding cleavage.	5	4
Dolomite, highly fractured, medium gray (N5), very finely megacrystalline to finely megacrystalline, weathering very light gray (N8); poorly developed, discontinuous rock cleavage striking N43°E and dipping 34°SE.	8	4
Limestone, medium gray (N5); abundant branching cylinders, lenses and lobes of dolomite weathering yellowish-gray (5Y8/1).	1	3
Concealed. Traverse N60°W, 10 feet; bedding N20°E, 30°NW.	4-1/2	3

	Thickness (feet) unit	total
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8); numerous fractures.	3	30-1/2
Concealed. Traverse N60° W, 10 feet; bedding N20°E, 30°NW.	4-1/2	27-1/2
Dolomite, medium dark gray (N4), medium megacrystalline.	1	23
Chert layer, dark gray (N3), weathering rusty brown.	1	22
Dolomite, medium gray (N5), finely megacrystalline.	1	21
Chert layer, weathering dark brown.	1	20
Dolomite, medium gray (N5), finely megacrystalline, weathering very light gray (N8).	2	19
Concealed. Traverse N60° W, 22 feet; bedding N20°E, 30°NW.	10-1/2	17
Concealed; dark-gray (N3) chert blocks and fragments.	2	6-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8) to light yellowish gray (5Y8/1), parting into 1-foot layers; indistinct laminae.	2-1/2	4-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8), gradational into limestone at top through zone of branching cylinders, lenses, and lobes of dolomite weathering yellowish gray (5Y8/1).	1	2
Concealed; dark gray chert boulders.	1	1
Total measured thickness of Ontelaunee Formation		74

	Thickness (fee	
	unit	tota
Epler Formation		
Concealed, traverse N60°W, 15 feet; bedding N14°E, 22°NW.	5-1/2	966-1
Limestone, medium gray (N5), very finely megacrystalline; imperfect bedding cleavage.	1	96
Dolomite, finely megacrystalline, weathering very light gray (N8); gradational with overlying unit through zone of dolomite laminae.	3-1/2	96
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8). Traverse N60°W, 110 feet; bedding N14°E, 22°NW.	39	956-1
Limestone, medium light gray (N6), very finely megacrystalline, weathering light gray (N7).	1	917-1
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8), parting into 1-foot layers.	4-1/2	916-1
Limestone, medium gray (N5); abundant dolomitic-mottling and laminae weathering yellowish gray (5Y8/1).	4-1/2	91
Concealed. Traverse N60°W, 70 feet; bedding N30°E, 29°NW.	33	907-1
Limestone, finely megacrystalline; dolomitic mottling concentrated in layers along bedding and weathering yellowish gray (5Y8/1). Traverse N60°W, 15 feet; bedding N20°E, 41°NW.	10	874-1
Concealed. Traverse N60°W, 65 feet; bedding N25°E, 27°NW.	29	864-1
Limestone, medium gray (N5), very finely megacrystalline with finely megacrystalline lenses; weathering very light gray (N8); yellowish-gray (5Y8/1)-weathering dolomitic mottling distorted parallel to trace of imperfect bedding cleavage. Traverse N60°W, 16 feet; bedding		

	Thickness (feet) unit	total
N25°E, 14°SE (?).	4	835-1/2
Concealed. Traverse N70°W, 940 feet to average strike of bedding N30°E; dip 20°NW. Partially exposed in sections 15.	330	831-1/2
Limestone, medium gray, very finely megacrystalline; numerous bands and lenses of finely-megacrystalline (pelmatozoan?) limestone; distinct bedding cleavage weathering with fluted surface; several thin, medium-calcarenite bands.	25	521-1/2
Alternating 1-foot to 3-foot beds of laminated, very finely megacrystalline limestone and laminated, medium-gray (N5) dolomite.	9	496-1/2
Limestone, medium gray (N5), very finely megacrystalline, laminated; zones of dolomitic mottling.	12	487-1/2
Alternating 1-foot to 3-foot beds of laminated very finely megacrystalline limestone and medium-gray (N5), very finely megacrystalline dolomite; dolomite weathering yellowish gray (5Y8/1); beds have been thrown into folds overturned to the northwest.	10-1/2	475-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); parting into 1-foot layers; regular parallel and wavy laminae; closely spaced fracture cleavage, N15°E, 45°E.	5	465-1/2
Limestone, medium gray (N5), very finely megacrystalline, laminated; pronounced fluting of bedding cleavage on light-gray (N7)-weathering surface.	10	460-1/2
Dolomite, medium gray (N5), very finely megacrystalline, laminated.	2	450-1/2
Limestone, medium gray (N5), very finely mega-		

	Thickness (fee	
	unit	tota
crystalline; numerous dolomite lenses weathering yellowish gray (5Y8/1).	2	448-1
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1-foot layers; regular wavy laminae.	4	446-1
Limestone, medium gray (N5), very finely megacrystalline, grading into overlying unit through 6-inch zone of sub-banded dolomite intergrowths weathering yellowish gray (5Y8/1).	2-1/2	442-1
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1-foot layers; regular parallel laminae.	3	44
Limestone, medium gray (N5), very finely megacrystalline, laminated; poorly developed bedding cleavage.	2	43
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish-gray (5Y8/1), parting into 1-foot layers.	8	43
Exposures; alternating beds of limestone and dolomite; poorly exposed folds; horizontal bedding west of fold axis not included in traverse. Traverse N80°W across inclined beds, 150 feet.	96	42
Limestone, medium gray (N5), very finely megacrystalline; imperfect bedding cleavage.	3	33
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	6	32
Limestone, medium gray (N5), very finely megacrystalline; bedding cleavage bends around numerous knot-like masses and lenses of dolomite.	3	32
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	4	31

	Thickness (feet) unit	total
Limestone, medium gray (N5), very finely megacrystalline; dolomite mottling and boudins; bedding cleavage.	10	315
Dolomite, highly fractured, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1). Transitional contacts.	8	305
Limestone, medium gray (N5), very finely megacrystalline; knot-like masses and irregular laminae of dolomite weathering yellowish gray (5Y8/1); upper 6 inches contains dolomitic mottling and cylindrical fucoidal-like structures.	10	297
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1-1/2	287
Limestone; well developed bedding cleavage bending around several dolomite boudins; limestone has apparently been forced into joint spacings in dolomite with subsequent rotation of dolomite blocks.	2	285-1/2
Dolomite, medium gray (N5), very finely megacrystalline.	1	283-1/2
Limestone, weathering very light gray (N8); well-developed bedding cleavage.	1/2	282-1/2
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1-foot layers; indistinct regular parallel laminae.	7	282
Limestone, medium gray (N5), very finely megacrystalline, laminated; dolomite mottling in uppermost 6 inches.	1	275
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1-1/2	274
Limestone, medium gray (N5), very finely megacrystalline; dolomite boudin completely surrounded by limestone in which bedding cleavage		

	Thickness (fee	
	unit	tot
bends around dolomite.	1	272-1
Dolomite, medium gray (N5), very finely megacrystalline to finely megacrystalline, regular laminae, weathering yellowish gray (5Y8/1), parting into 1-foot layers.	8-1/2	271-1
Limestone; patches and lenses of yellowish-gray-weathering (5Y8/1) dolomite grading upward into 6 inches of dolomitic-laminated limestone.	1-1/2	26
Limestone, medium gray (N5), very finely megacrystalline, laminated, transitional upper and lower contacts; imperfect bedding cleavage.	1/2	261-1
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); regular wavy laminae.	2	26
Limestone, medium gray (N5), very finely megacrystalline; lower 6 inches of lensing laminae weathering yellowish gray (5Y8/1); bedding cleavage.	1-1/2	2[illegible]
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8), parting into 1/2-foot layers; spaced, discontinuous rock cleavage N25°E, 28°SE.	4	257-1
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); regular parallel laminae; poorly developed fracture cleavage.	2	253-
Limestone, medium gray (N5), very finely megacrystalline; calcarenite lenses with intergranular dolomite; contorted masses, knots and irregular discontinuous bands of dolomite.	5	251-
Dolomite, medium gray (N5), finely megacrystalline, weathering yellowish gray (5Y8/1); calcite grains in upper 4 inches.		

	Thickness (feet) unit	total
Limestone, medium gray (N5), very finely megacrystalline, laminated; bedding cleavage; measurement in crest of small fold.	12	246-1/2
Dolomite, medium gray (N5), very finely megacrystalline to finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 2-foot layers.	4	234-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8); elongate chert lenses and stringers bend around crests of small folds.	2-1/2	230-1/2
Limestone, medium gray (N5), very finely megacrystalline; irregularly banded by micro-folded siliceous laminae weathering black (N1); bedding cleavage bends around "knots" of dolomite; transitional with overlying unit through zone of very irregular, wavy dolomitic laminae.	4-1/2	228
Dolomite, medium gray (N5), very finely megacrystalline; zone of dolomitic bioclastic pebble calcarenite at top, grading into overlying limestone; weathering very light gray (N8); 2-inch-thick, elongated, dark-gray coalescing chert nodules restricted to bedding.	1-1/2	223-1/2
Dolomite, medium gray (N5), very finely megacrystalline to finely megacrystalline, weathering light gray (N7), parting into 1-foot layers; regular parallel laminae.	4-1/2	222
Dolomite, medium gray (N5), very finely megacrystalline, irregular, thin, wavy siliceous laminae swelling locally into 1-inch to 2-inch elongate, contorted chert masses.	1-1/2	217-1/2
Limestone, medium gray (N5), very finely megacrystalline; yellowish-gray-weathering (5Y8/1) lobes and lenses of dolomite distorted parallel to traces of bedding cleavage; thickness estimated.	8	216

	Thickness (feet) unit	total
Dolomite, highly fractured, medium gray (N5), finely megacrystalline, poorly exposed; beds folded and possibly faulted; estimated thickness.	6	20
Dolomite, medium gray (N5), very finely megacrystalline; indistinct laminae.	2-1/2	20
Limestone, medium gray (N5), very finely megacrystalline; lenses and lobes of dolomite distorted parallel to traces of bedding cleavage.	2	199-1/
Dolomite, medium gray (N5), finely megacrystalline, irregularly banded by stylolitic and discontinuous wavy partings; partially concealed fold obscures upper contact relation.	4	197-1/
Limestone, medium gray (N5), very finely megacrystalline, laminated; distorted dolomite mottling grading into adjacent units.	3-1/2	193-1/
Dolomite, medium light gray (N6), finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 6-inch layers.	2	19
Limestone, medium gray (N5), very finely megacrystalline; 1-inch, irregular, micro-folded bands weathering black (N1); cleavage N52°E, 54°SE.	1	18
Dolomite, medium gray (N5), finely megacrystalline, parting into 1-foot layers; zone of angular, elongate dolomite fragments at top, fragments concentrated along bedding; regular parallel laminae; stylolitic partings common.	5	18
Dolomite, medium gray (N5), finely megacrystalline, parting into discontinuous 1/2-foot layers; irregular, crinkly to wavy laminae weathering black (N1); two zones of dolomitic-mottled limestone 6 inches and 1 foot above base.	4	18
Dolomite, medium gray (N5), very finely mega-		

	Thickness (feet) unit	total
crystalline, weathering yellowish gray (5Y8/1); indistinct laminae.	2	178
Dolomite, irregularly fractured, medium gray (N5), finely megacrystalline; few zones of indistinct laminae; top 6 feet contains folded limestone beds.	11	176
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray, parting into 1/2-foot layers; indistinct laminae.	4	165
Dolomite, highly fractured, medium gray (N5), finely megacrystalline to very finely megacrystalline, parting into 1/2-foot layers.	8	161
Dolomite, medium dark gray (N4), finely megacrystalline, laminated.	1/2	153
Dolomite, medium gray (N5), finely megacrystalline, weathering yellowish gray (5Y8/1).	1/2	152-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 3-inch layers; parallel laminae.	1/2	152
Dolomite, medium gray (N5), finely megacrystalline, parting into 1/2-foot layers; 1-foot zone of discontinuous, wavy to crinkly, laminae at top.	5-1/2	151-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2-foot layers; regular parallel laminae.	3	146
Limestone, medium gray (N5), very finely megacrystalline; bedding cleavage.	1	143
Dolomite, moderately effervescent, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2-foot layers; regular parallel dolomitic and calcareous		

	Thickness (fee unit	tota
laminae weather inward giving unit a thinly ribbed appearance; gradational with overlying unit.	1-1/2	14
Dolomite, medium gray (N5), very finely megacrystalline; indistinct laminae.	1-1/2	140-1
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1/2-foot layers; micro-folded laminae indicate overturned beds with tops to the west.	4	13
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1-1/2	13
Dolomite, medium gray (N5), finely megacrystalline; irregular, discontinuous, crinkly to wavy laminae.	2	133-1
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	10-1/2	131-1
Dolomite, slowly effervescent, medium gray (N5), finely megacrystalline, parting into 1-3/4-foot layers; indistinct calcitic lenses and lobes.	3-1/2	12
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8); indistinct laminae; well developed joints.	2	117-1
Limestone, medium light gray (N6), very finely megacrystalline, parting into 4-inch discontinuous layers; limestone surrounds small dolomite boudins; spaced, discontinuous rock cleavage, N58°E, 48°SE.	3-1/2	115-1
Dolomite, medium gray (N5), finely megacrystalline weathering yellowish gray (5Y8/1), parting into 1/2 to 2-foot layers; irregularly spaced, wavy siliceous and dolomitic laminae in uppermost 11 feet.	13-1/2	11

	Thickness (feet) unit	total
Limestone, medium gray (N5), cryptogranular; irregular dolomitic lobes and lenses; upper 6 inches contains 2-inch-thick, dark-gray (N3) chert nodules and stringers.	4	98-1/2
- Measurement of 21.5 feet of beds below is approximate. Beds have been shattered and faulted rendering accurate measurements difficult. -		
Dolomite, medium gray (N5), very finely mega-crystalline, weathering yellowish gray (5Y8/1), parting into 2-foot layers; indistinct laminae.	6-1/2	94-1/2
Limestone, medium gray (N5), very finely mega-crystalline; imperfect bedding cleavage bends around enclosed dolomite boudins; zone of dolomite mottling at top grades into overlying unit.	4	88
Dolomite, medium gray (N5), very finely mega-crystalline, weathering yellowish gray (5Y8/1), parting into 6-inch layers; regular parallel laminae.	8-1/2	84
Limestone, medium gray (N5), cryptogranular; irregular pebble calcarenite zones 6 inches and 2-1/2 feet above base; unit irregularly-bounded by micro-folded laminae weathering black (N1); micro-folds indicate bedding is upright with tops to the east; the micro-folds are not well developed and this section is interpreted as an anomalous relation between drag folds in this unit and the major fold axis.	4-1/2	75-1/2
Dolomite, medium gray (N5), very finely mega-crystalline, weathering very light gray (N8), parting into 4-inch layers; regular parallel laminae.	2-1/2	71
Dolomite, medium gray (N5), very finely mega-crystalline, weathering yellowish gray (5Y8/1) with smoothly weathering surface, parting into		

	Thickness (feet) unit	total
2-foot to 4-foot layers; several 1-foot zones of regular parallel laminae.	9	68-1,
- Top of quartzose zone. -		
Dolomite, medium gray (N5), very finely megacrystalline, parting into 2- to 4-inch layers; regular parallel laminae; few dark-gray (N3) chert nodules; several zones of rounded, medium-sand-size quartz grains in middle of unit.	3	59-1,
Limestone, medium light gray (N6), cryptogranular; laminated; bedding cleavage.	2	56-1,
Dolomite, medium gray (N5), very finely megacrystalline, parting into 2-foot layers; indistinct regular laminae; few zones of rounded quartz sand grains at top and of 1-inch to 3-inch chert nodules.	4	54-1,
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1-foot layers; 1-inch to 4-inch bands of regular parallel laminae separating 1-inch to 4-inch non-laminated bands; 4-inch zones of rounded, medium-sand-size quartz grains in upper 2 feet; chert nodules associated with sandy zones.	4	50-1,
Dolomite, medium dark gray (N4), very finely megacrystalline, laminated.	1/2	46-1,
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 3-foot layers.	6	4
Limestone, medium gray (N5) to medium light gray (N6), calcilutitic in part, regularly laminated; parting along bedding cleavage; brownish weathering discontinuous siliceous micro-folded laminae weathering into strong relief; angular blocks of dolomite enclosed in limestone with concentratings of cherty		

	Thickness (feet) unit	total
material surrounding the dolomite.	1-1/2	40
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 3-foot layers; several 1-foot zones of indistinct laminae; 2 or 3, 1-inch, irregular bands of dark-gray (N3), rusty-brown-weathering chert.	19	38-1/2
Concealed.	7	19-1/2
Dolomite, medium gray (N5), finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2- to 1-foot layers; several 6-inch zones of light-brown-weathering crinkly to wavy laminae.	7	21-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1) with smooth surface; parting into 1-foot layers; indistinct laminae.	4-1/2	14-1/2
Limestone, very finely megacrystalline, imperfect bedding cleavage; bed lenses owing to pinching out of the limestone between the underlying and overlying dolomite beds in places.	1	10
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1/2	9
Dolomite, medium gray (N5), finely megacrystalline; irregular masses and anastomosing stringers of dark-gray chert.	1/2	8-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	2	8
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2- to 1-foot layers; regular parallel and inclined laminae.	4-1/2	6
Limestone, with developed shaly parting along		

	Thickness (feet) unit	total
bedding cleavage, medium gray (N5) to medium light gray (N6) with pinkish tinge, weathering very light gray, laminated; 1-inch to 2-inch bed of dark-gray chert at top and laminated chert at base, weathering rusty brown.	1-1/2	1-1/
Measured thickness of Epler Formation		1043-1/
Rickenbach Dolomite Upper member		
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2-foot layers.	1	139
Dolomite, medium gray (N5), microcrystalline; crinkly to wavy, brownish-weathering laminae; poorly-developed shaly partings.	1/2	138
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1-inch to 1-foot layers; distinct, regular parallel laminae in lower 1 foot.	3	137-1/
Dolomite, medium light gray (N6), very finely megacrystalline to finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1-foot layers; 1-inch to 3-inch bands of indistinct, regular parallel laminae, 2-inch-thick stringers of dark-gray chert 6 inches below top; several thin laminae of quartz sand grains below chert.	4	134-1/
Dolomite, medium light gray (N6), finely megacrystalline; discontinuous laminae and bands; 1/4-inch, sub-nodular masses of white chert in upper 1 foot.	2	130-1/
Concealed.	6	128-1/
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray		

	Thickness (feet) unit	total
(5Y8/1), parting into 1- to 3-foot layers; indistinct laminae; numerous thin laminae of rounded, medium-sand quartz grains in upper 1-1/2 feet; poorly developed graded bedding indicates tops to the west; 2-inch dark-gray chert bed at top.	6	122-1/2
- Base of quartzose zone (91 feet thick). -		
Dolomite, medium light gray (N6), very finely megacrystalline to microcrystalline, weathering yellowish gray (5Y8/1), parting into 3-inch to 3-foot layers; indistinct laminae.	8	116-1/2
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1-foot layers; alternating 1/4-inch to 3-inch bands of regular parallel laminae and 1-inch to 4-inch non-laminated bands; 4-inch, dark-gray chert bed 3 feet above base; extensive nodules, stringers and 1/4-inch circular masses of white chert in uppermost 3 feet.	5	108-1/2
Concealed.	13	103-1/2
Dolomite, medium light gray (N6), finely megacrystalline with zones of very finely megacrystalline to microcrystalline texture, weathering yellowish gray (5Y8/1), parting into 1-foot layers in lower 5 feet; 1 foot bed 4 feet above base contains 1/4-inch circular patches of sparry dolomite.	10-1/2	90-1/2
Concealed.	3	80
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 4-foot layers; four 1-inch-thick, 1-foot- to 6-foot-long, brown-weathering, dark-gray chert stringers in uppermost 4 feet; closely spaced joints.	9-1/2	77

	Thickness (feet) unit	total
Dolomite, medium gray (N5), finely megacrystalline, weathering medium light gray (N6).	3	67-1/
Concealed.	14-1/2	64-1/
Dolomite, medium gray (N5), very finely megacrystalline, weathering light yellowish gray (5Y8/1); indistinct laminae; 2-inch lensing, dark-gray (N3) chert bed several inches above base.	1-1/2	50
Exposures; dolomite, medium light gray (N6), very finely megacrystalline to microcrystalline with scattered finely megacrystalline lenses, weathering very light gray (N8); punky-weathering 6-inch chert bed 6 feet above base; thin bed of medium-dark-gray (N4), finely-megacrystalline to coarsely-megacrystalline dolomite 1 foot below top of unit.	12	48-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 2-foot layers; alternating 1/4-inch to 3-inch bands of regular parallel and cross-bedded, silty laminae and irregular 1-inch to 3-inch bands of non-laminated dolomite; brownish-weathering, 1-inch to 1-foot chert stringers in middle; cross-bedding indicates tops to the west.	4	36-1/2
Concealed.	2	32-1/2
Dolomite, very slowly effervescent, medium light gray (N6), finely megacrystalline, weathering very light gray (N8) with yellowish tinge, parting into 4-foot layers; irregular 1/4-inch-long chert stringers.	7-1/2	30-1/2
Concealed. Traverse 24 feet due west. Dolomite float.	23	23
Measured thickness of upper member.		139

	Thickness (feet) unit	total
Lower member		
Dolomite, medium gray (N5), finely megacrystalline to medium megacrystalline, weathering light gray (N7) with "gritty" surface; regular parallel laminae in middle.	2-1/2	7
Concealed; punky weathering chert fragments.	1-1/2	4-1/2
Dolomite, medium light gray (N6), finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 2-foot layers; discontinuous, wavy, dark-gray (N3), siliceous laminae in lower 2 feet, weathering into strong relief.	3	3
Exposed thickness of lower member.		7
Total exposed thickness of Rickenbach Dolomite.		146
Stonehenge Limestone		
Concealed. Traverse N10°E, 645 feet; average bedding strike N45°E and dip 15°SW. Probably includes upper Stonehenge formation.	335	700-1/2
Exposures; limestone, medium gray (N5), very finely megacrystalline, weathering very light gray (N8). Traverse 280 feet, N10°E; bedding N45°W, 15°SW.	60	365-1/2
Limestone, medium gray (N5), very finely megacrystalline; 6-foot zone 6 feet above base of 4 regularly spaced horizons of black-chert nodules; 1-foot bed of yellowish-gray (5Y8/1) -weathering dolomite in middle of unit. Thickness estimated from west wall of quarry.	25	305-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); bedding surface with pronounced asymmetric undulations 1/8-inch high and 1/2-inch in wave length, resembling current ripple markings.	2	280-1/2

	Thickness (feet) unit	total
Limestone, medium gray (N5), cryptogranular; irregular brownish- to black-weathering laminae.	2-1/2	278-1/
Limestone, medium gray (N5), very finely megacrystalline; scattered and clustered euhedra of yellowish-gray (5Y8/1)-weathering dolomite; 2 inches of regular dolomite laminae at base; 1-foot stringers of black chert at top.	1/2	276
Limestone, medium gray (N5), very finely megacrystalline; alternating bands of black (N1)-weathering, micro-folded laminae and of yellowish-gray (5Y8/1)-weathering dolomite euhedra; gradational with underlying unit through 3-inch zone of contorted stringers of dolomite; small folds varying in size from micro-folds to a larger recumbent fold; unit contains 1-inch to 6-inch stringers of black chert.	2	275-1/
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); recumbently micro-folded laminae.	1/2	273-1/
Limestone, medium gray (N5), very finely megacrystalline; laminae with recumbent micro-folds; 2-inch, black-chert nodules; 1-foot zone of disseminated and clustered dolomite euhedra.	4	273
Limestone, medium gray (N5), disseminated 1/4-inch to 1/2-inch-long, branching cylindrical dolomite structures weathering yellowish gray (5Y8/1).	3	269
Limestone, very finely megacrystalline, parting into 1-foot layers; wavy, irregular micro-folded laminae; imperfect bedding cleabage; 1-foot zone 6 inches above base of disseminated and clustered dolomite euhedra; uppermost 6 inches contains lenses and irregular masses of very finely megacrystalline dolomite; dolomite varies from characteristic unit crystals to		

	Thickness (feet) unit	total
solid masses; few irregular masses of black (N1) chert, the largest of which is 4 inches to 5 inches long.	3	266
Dolomite, medium gray (N5), very finely megacrystalline to finely megacrystalline, weathering yellowish gray (5Y8/1); regular laminae; small lenses of indistinct micro-breccia at base.	1	263
Limestone, medium light gray (N6), very finely megacrystalline, weathering light gray (N7), small micro-folded and distorted lenses of dolomite weathering yellowish gray (5Y8/1); 1-inch- to 5-inch-long, very irregular, black (N1) chert stringers; several stringers bend around micro-fold crests and troughs.	1	262
Dolomite, very finely megacrystalline, medium gray (N5), weathering light yellowish gray (5Y8/1); chert-filled fractures; indistinct laminae.	1	261
Concealed. Traverse 1225 feet, N80°E; bedding N45°W, 15°SW.	260	260
- Exposures; limestone, calcirudite ("edgewise conglomerate"). One foot to 2 feet of these beds are exposed in fault contact with or unconformable on beds of Cambrian limestone and dolomite. -		
Exposed thickness of Stonehenge limestone		365-1/2
Apparent total thickness of Stonehenge Limestone		700-1/2

Cambrian System

Conococheague limestone and dolomite.	not measured	

SECTION NUMBER 15

Myerstown, Pennsylvania — Date described: July, 1956; Date sampled: September, 1956

Location and structure of section

Section No. 15 is exposed in cut along railroad tracks of Reading Company immediately southeast of borough limits of Myerstown, Pennsylvania, in Lebanon quadrangle at approximately 1.80 miles east of 76° 20' longitude and 2.20 miles north of 40° 20' latitude (Fig. 26).

As indicated by five readings, beds strike N60°E and dip 35°SE overturned. Poorly developed cleavage in the limestones strikes N50°E to N60°E and dips 5°SE to 20°SE. Two high angle faults are exposed 75 feet apart in the middle of cut. Eastern fault strikes N25°W and dips 85°NE. Western fault strikes N12°W and dips 90°. Gash fractures along east edge of western fault indicate that eastern side has moved relatively upward. Dolomites exposed between faults are of general lithology ascribed to beds younger than strata cut by the fault block. Hence, it would appear that the dolomite has been raised between faults into its present position. Joints are especially prominent in the dolomite beds. No joint readings recorded. Measurements of thickness made directly on bedding.

Section description	Thickness (feet) unit	total
Annville Limestone		
- Exposures in quarry 800 feet east of Myerstown borough limits. -		
Concealed. Map traverse 2300 feet about S80°E; assumed bedding strike about N80°E and dip of 35°SE overturned; probably an unreliable value for true stratigraphic thickness of concealed beds owing to numerous flexures characteristic of the immediate area.		1300
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Dolomite, mediumlight gray (N6), very finely megacrystalline, parting into 3- to 6-inch		

	Thickness (feet) unit	total
layers; indistinct laminae; several 1-inch to 2-inch, non-laminated bands. No sample.	5	34-1/2
Dolomite, calcitic, medium gray (N5); very-finely-megacrystalline, anastomosing, lobes and lenses weathering yellowish gray (5Y8/1) cover 70 percent of surface area. Sample no. BL6-3-26.	1	29-1/2
Dolomite, medium gray (N5), finely megacrystalline, parting into 1/2-foot layers; several medium-megacrystalline beds; zone of dark-gray (N3) chert nodules 2 feet above base. No sample.	6-1/2	28-1/2
Limestone, medium gray (N5), cryptogranular; disseminated, yellowish-gray-weathering (5Y 8/1) dolomite euhedra increasing in number upwards through discontinuous sub-banded clusters into overlying dolomite unit. No sample.	1	22
Dolomite, medium gray (N5) with medium-light gray (N6) interbeds, finely to medium megacrystalline, parting into 1/2-foot layers; numerous scattered nodular and sub-nodular masses of dark-gray (N3) chert. No sample.	9	21
Dolomite, medium gray (N5) with irregular, wavy to crinkly, medium-dark-gray (N4) laminae, finely to medium megacrystalline, weathering with rough "gritty" surface. Sample no. BL5-3-25 in middle.	3	12
Limestone, medium gray (N5), smoothly fracturing cryptogranular, weathering light gray (N7); very irregular bed of dark-gray (N3) chert at top contact; chert brecciated locally into small angular blocks; transitional with overlying unit through zone of clustered and disseminated dolomite euhedra. Sample no. BL6-3-24.	2	9

	Thickness (feet) unit	total
Dolomite, with distinct medium-gray (N5) and medium-dark-gray (N4) laminae, parting into irregular 3-inch layers; "gritty"-weathering surface; 2 zones of coalescing nodules of medium-dark-gray (N4) chert. Sample no. BL6-3-23.	4-1/2	7
Dolomite, medium light gray (N6), microcrystalline, weathering yellowish gray (5Y8/1); indistinct parallel laminae. No sample.	1-1/2	2-1/
Dolomite, moderately effervescent, medium gray (N5), medium to coarsely megacrystalline; "gritty"-weathering surface. Sample no. BL6-3-22.	1/2	1
Chert; irregular bed, medium dark gray (N4); smooth even base; uneven upper surface. Sample no. BL6-3-21.	1/2	1/
Exposed thickness of Ontelaunee Formation		34-1/
Epler Formation		
Concealed.	6	182
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1-foot layers; indistinct laminae. No sample.	4-1/2	176
Dolomite, medium gray (N5) to medium light gray (N6), medium megacrystalline; "gritty"-weathering surface. No sample.	1	171-1/
Limestone, medium gray (N5) to medium dark gray (N4), smoothly fracturing cryptogranular, gradational with adjacent dolomite units through zones of yellowish-gray-weathering (5Y8/1) dolomite mottling.	1/2	170-1/
Exposures; dolomite, medium gray (N5), medium megacrystalline, weathering medium light gray		

	Thickness (feet) unit	total
(N6) with "gritty" surface.	5-1/2	170
Dolomite, calcitic, medium gray (N5), roughly fracturing cryptogranular; 80 percent of unit light-gray (N7), finely megacrystalline dolomite with fucoidal-like arrangement on bedding.	1-1/2	164-1/2
Dolomite, medium gray (N5), finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 2-foot layers.	25	163
Limestone, medium gray (N5) to medium light gray (N6), smoothly fracturing cryptogranular, laminated at top.	2	138
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1).	3	136
Dolomite, medium light gray (N6), finely megacrystalline, weathering very light gray (N8), parting into irregular 2-inch layers; well developed joints and fractures.	4	133
Limestone, medium gray (N5) to medium light gray (N6), smoothly fracturing cryptogranular, weathering very light gray (N8), irregularly-banded by siliceous micro-folded laminae weathering black (N1).	9	129
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2-foot layers; regular parallel laminae.	4	120
Limestone, medium gray (N5), very finely megacrystalline; 2-inch pebble calcarenite bed at base with disseminated dolomite euhedra; unit irregularly banded by micro-folded laminae weathering yellowish gray (5Y8/1); well-developed rock cleavage.	3	116
Dolomite, medium gray (N5), finely megacrys-		

	Thickness (feet) unit	total
talline, weathering light gray (N7), laminated in lower 1/2, parting into 1/2- to 1-foot layers; pitted- to vuggy-weathering in upper 2-1/2 feet.	5-1/2	113
Limestone, medium gray (N5), smoothly fracturing cryptogranular; very finely megacrystalline, patchy, dolomitic intergrowths.	1-1/2	107-1/
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1-foot layers, laminated on weathered surface.	10	106
Limestone, medium gray (N5), roughly fracturing cryptogranular; discontinuous rock cleavage.	4	96
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), laminated on weathered surface, parting into 1-foot layers.	2	92
Limestone, medium gray (N5), roughly fracturing cryptogranular; small lenses of bioclastic calcarenite; very finely megacrystalline dolomite in anastomosing lobes and lenses.	2	90
Dolomite, medium light gray (N6), very finely megacrystalline, parting into 1-foot layers; several zones of indistinct laminae.	13	88
Limestone, medium gray (N5), smoothly fracturing cryptogranular; dark-gray (N3) shaly layers at top.	2	75
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 4-inch layers; regular parallel laminae; 1-inch of medium-dark-gray (N4) laminae at top.	2	73
Limestone, medium gray (N5), smoothly fracturing cryptogranular, parting into 1/2- to 1-		

	Thickness (feet) unit	total
foot layers; scattered calcarenite lenses; calcirudite zone at base; unit banded by yellowish-gray-weathering (5Y8/1) micro-folded laminae concentrated in places in 1-inch to 2-inch bands; laminated dolomite zone 2 feet above base with gradational, dolomitic-mottled contacts. Specimens of Hormotoma sp., and Ophileta sp. Samples no. BL6-3-20 at top; no. BL6-3-19 at 3 feet; no. BL6-3-18 at base.	6	71
Dolomite, medium light gray (N6), very finely megacrystalline; regular parallel laminae. Sample no. BL6-3-17 at base.	2	65
Limestone, medium gray (N5), parting into 1/2-foot layers; coarse bioclastic calcarenite with 1/2-mm. to 2-mm. rounded, calcilutite grains and fragments of fine-grained limestone in sparry calcite cement, several zones of bioclastic material.	7	63
Dolomite, moderately effervescent, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2- to 1-foot layers; stylolitic partings; unit grades through zone of dolomitic mottling into underlying limestone; upper contact is abrupt; bioclastics in upper 3 inches. Samples no. BL6-3-14 at top; no. BL6-3-13 at 3 feet above base.	4-1/2	56
Limestone, medium gray (N5), smoothly fracturing cryptogranular with scattered and clustered 1/2-mm. sparry carbonate crystals and shelly bioclastics; proportion of lenses and lobes of dolomite increase upward into 6-inch dolomite zone. Samples no. BL6-3-12; no. BL6-3-11.	4-1/2	51-1/2
Limestone, medium gray (N5), parting into 4-inch to 1-foot layers; several rock body repetitions of following lithologies: 1-inch zone of bioclastic pebble calcarenite overlain by irregular 1-inch to 2-inch band of medium-		

	Thickness (feet) unit	total
light gray (N6), very finely megacrystalline, calcareous dolomite which is overlain in turn by 3-inch to 4-inch zone of laminated to streaked dolomite. Sample no. BL6-3-9 in upper 6 inches.	3-1/2	47
Limestone, medium gray (N5), smoothly fracturing cryptogranular, parting into 4-inch to 1-foot layers; anastomosing lenses and lobes of dolomite weathering yellowish gray (5Y8/1). Sample no. BL6-3-8.	3	43-1/2
-Fault block; section continued in hanging wall of eastermost fault. -		
Limestone, medium gray (N5), smoothly fracturing cryptogranular; lenses of bioclastic calcarenite with 1/4-mm. to 1-mm., rounded, calcite grains in sparry calcite cement; upper 3 feet dolomitic-laminated and with dolomitic mottling in form of anastomosing lenses and lobes. Samples no. BL6-3-7 in upper 3 feet; no. BL6-3-6 in lower 3 feet.	6	40-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular; zones of bioclastic calcarenite with 1/8-inch to 1/4-inch, rounded calcite grains; calcarenite zones separated by irregular bands and stringers of dolomite; dolomite increases upward through zone of sub-banded dolomite lenses into overlying limestone.	1/2	34-1/2
Limestone, medium gray (N5), roughly fracturing cryptogranular, parting in middle; irregular lenses, lobes and stringers of very-finely-megacrystalline dolomite in sub-bands; thin stylolites.	1-1/2	34
Limestone, medium gray (N5), smoothly fracturing cryptogranular; irregular micro-folded laminae weathering yellowish gray (5Y8/1) to black (N1).	2	32-1/2

	Thickness (feet) unit	total
Limestone, medium gray (N5), smoothly fracturing cryptogranular, parting into 4-inch layers; calcarenite lenses increase in number toward base; numerous irregular lenses and stringers of medium-light-gray (N6), finely megacrystalline dolomite; scour surface contact with overlying unit; gradational with overlying unit. Sample no. BL6-3-4.	1-1/2	30-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 4- to 6-inch layers.	1-1/2	29
Limestone, medium gray (N5), roughly fracturing cryptogranular; disseminated sparry calcite crystals; lenses of bioclastic calcarenite increasing in proportion upward; calcarenite bed in upper 1 foot; dolomite bands and stringers weathering yellowish gray (5Y8/1) are associated with calcarenite and grade into overlying dolomite unit; well developed rock cleavage.	4-1/2	27-1/2
Dolomite, moderately effervescent, medium gray (N5), very finely megacrystalline; irregular clusters of bioclastics; shells weather into shallow pits in dolomite cement weathering yellowish gray (5Y8/1). Sample no. BL6-3-3.	1	23
Limestone, medium gray (N5), medium pelmatozoan calcarenite; bands and irregular intergrowths of dolomite. Sample no. BL6-3-2.	1/2	22
Limestone, medium gray (N5), parting into 2-inch layers; coalescing 1/2-inch to 1-inch, laminated, medium-dark-gray (N4) siliceous bands in medium-gray cryptogranular limestone with sparry calcite crystals; bands weather yellowish gray (5Y8/1) to yellowish orange; grades into overlying unit.	2	21-1/2
Dolomite, medium gray (N5), finely megacrystalline; weathering yellowish gray (5Y8/1),		

	Thickness (feet	
	unit	total
parting into 6-inch layers.	4	19-1/
Limestone, medium gray (N5), cryptogranular with disseminated 1/8-mm. sparry calcite crystals and scattered 1/2-mm. to 1-mm. sparry calcite crystals, parting into 2- to 4-inch layers; lenses and 2-inch to 4-inch irregular beds of medium to coarse calcarenite with 1/4-inch to 1-inch-long, rounded, elongate to equant, limestone pebbles; irregular development of yellowish-gray-weathering (5Y8/1) intergranular dolomite in thin bands, laminae and cylindrical structures; deeply-weathered along rock cleavage and bedding. Sample no. BL6-3-1 at 8 feet above base.	15-1/2	15-1/
Exposed thickness of Epler Formation		182

SECTION NUMBER 16

ₗamona, Pennsylvania Date described: July, 1956

ₗocation and structure of section

Lower part of Section No. 16 is located in cut along south side of ₗeading Company's railroad tracks 0.20 mile east of crossing at Ramona, ²ennsylvania, in Lebanon quadrangle at approximately 0.75 mile east of '6° 20' longitude and 2.20 miles north of 40° 20' latitude (16a, Fig. 26).

Beds strike N55°E to N60°E and dip 90°SE to 85°SE overturned.)verturning indicated by occurrence of older chert beds to south and ounger Annville limestone to north. Measurements, beginning at owest bed exposed, made with 8-foot tape perpendicular to bedding.

Annville limestone exposed in two small quarrys (16b, Fig. 26) bout 2000 feet due north of section. Apparent stratigraphic thickness n concealed interval between exposures of Annville limestone and)ntelaunee dolomite may be unreliable owing perhaps to an easterly xtension of a flexure described by Gray (1952) in large quarry (16c, 'ig. 26) about 5000 feet to west of section. Therefore, estimate of hickness between base of Annville limestone and chert beds of Ontelaunee olomite has been made from concealed interval south of large quarry, ocated on Ulrich property. Paced traverse distance S15°E, 1200 feet rom Annville limestone to first appearance of chert float about 350 feet outh of railroad tracks; average bedding strike N80°E and average dip 0°SE overturned. On this basis 750 to 850 feet of apparent stratigraphic hickness separate the base of Annville limestone from the chert beds vest of Ramona; therefore, an estimated 535 feet of beds separates asal Annville limestone from top exposure in section 16, which is 265 eet thick.

ection description	Thickness (feet) unit	total
Middle Ordovician Series		
Annville Limestone		
Limestone, medium gray (N5) to light gray (N7), megacrystalline, pure; dark and light sub-laminated and sub-banded mottling at base.	not measured	
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		

	Thickness (feet) unit	total
Concealed. See discussion under "location and structure of section."	535	800
Limestone, medium gray (N5), very finely megacrystalline; numerous branching, cylindrical fucoidal structures weathering yellowish gray (5Y8/1).	2	265
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 3-foot layers; zones of indistinct laminae.	23	263
Limestone, medium gray (N5), smoothly fracturing cryptogranular; interconnected lobes and irregular stringers of yellowish-gray-weathering (5Y8/1) dolomite increasing in proportion toward contacts; imperfect bedding cleavage; dolomite structures distorted parallel to trace of foliation.	1	240
Dolomite, medium gray (N5), very finely megacrystalline.	1/2	239
Limestone, medium gray (N5), finely megacrystalline; interconnected lobes and irregular stringers of dolomite.	1	238-1/
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1- to 2-foot layers; closely spaced jointing; fractured.	7	237-1/
Limestone, very finely megacrystalline, dolomitic mottled.	2	230-1/
Dolomite, medium gray (N5), very finely megacrystalline weathering yellowish gray (5Y8/1), parting into 1- to 4-foot layers; well-developed joints; fractured.	18-1/2	228-1/
Dolomite, medium dark gray (N4), very finely megacrystalline, laminated.	2-1/2	210

	Thickness (feet) unit	total
Exposures; dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 4-foot layers.	65	207-1/2
Dolomite, mottled medium gray (N5) to medium dark gray (N4), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1/2-foot layers.	1-1/2	142-1/2
Dolomite, medium light gray (N6), very finely megacrystalline, parting into 1-foot layers; zones of indistinct laminae; stylolitic partings.	12-1/2	141
Dolomite, medium light gray (N6), very finely to finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 2-foot layers.	10-1/2	128-1/2
Limestone, medium gray (N5) to medium light gray (N6), very finely megacrystalline, laminated; dolomite mottling at contacts.	1	118
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 2-foot layers.	6-1/2	117
Limestone, medium gray (N5), very finely megacrystalline laminated.	1/2	110-1/2
Concealed.	5-1/2	110
Exposures; dolomite, medium gray (N5) to medium dark gray (N4), finely to medium megacrystalline.	2	104-1/2
Concealed.	13-1/2	102-1/2
Exposures; alternating beds of finely megacrystalline limestone and very finely megacrystalline dolomite.	4	89

	Thickness (feet) unit	total
Concealed. Traverse N75°E, 155 feet; bedding strikes N55°SE, dips 75°SE; exposures at east end of traverse of medium-gray (N5) to medium-light-gray (N6), very finely megacrystalline, dolomite in 1-foot to 3-foot layers, weathering yellowish gray (5Y8/1).	50	85
Estimated apparent stratigraphic thickness to dark-gray chert fragments in field immediately south of tracks.	35	35
Exposed thickness of Ontelaunee Formation		265
Concealed thickness of Ontelaunee Formation		535
Total estimated thickness of Ontelaunee Formation		800

SECTION NUMBER 17

alcite Company quarry
rescott, Pennsylvania — Date described: July, 1956

ocation and structure of section

Section No. 17 is exposed in road cut through south wall of central uarry on property of Calcite Company 1.2 miles east of Avon, Pennsyl-ania and 1000 feet south of U.S. Route 422, in Lebanon quadrangle at pproximately 1.15 miles west of 76° 20' longitude and 1.85 miles north f 40° 20' latitude (Fig. 26).

As indicated by two readings, beds strike N60°E and dip 40°SE verturned. At least two faults are visible and strike N70°W to N90°W nd dip 70°NE to 80°NE. Slickensides plunging at low angle to the west n fault surfaces indicate movement essentially parallel to strike of ıult surfaces.

Measurements of unit thicknesses made directly with 8-foot tape xcept where traverse data given. Section begins at contact with Ann-ille limestone along south wall of quarry and continues southeastward › entrance for quarry road.

ection description	Thickness (feet) unit	total
Annville Limestone		
Limestone, medium light gray (N6), very finely megacrystalline; dark-gray (N3) laminae, streaks and mottling; separated from underlying dolomites by sharp, unwelded, slickensided contact.	not measured	
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Formation		
Dolomite, medium gray (N5) to medium dark gray (N4) with dark-gray (N3) interbeds, very finely to finely megacrystalline, laminated in part, parting into 5-foot to 25-foot layers; stylolitic seams and black carbonaceous shaly layers common. Rock weathers a deep medium gray (N5) to light gray (N7) and the true fresh color may be observed only in recently quarried		

	Thickness (fee unit	tot:
rock. Measured perpendicular to bedding the unit is 210 feet thick. Probably this thickness reflects repetition of strata along faults similar to that observed in eastern wall of quarry where Annville limestone is repeated by strike movement along longitudinal faults. At least one northwestward-striking fault is exposed in dolomite. True thickness may be between 100 feet and 150 feet. Estimated thickness.	125	286-1
Dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline, jointed, parting into 1- to 3-foot layers.	15-1/2	161-1,
Limestone, very light gray (N8), finely megacrystalline, parting into 2-inch layers; dark-gray (N3) streaks and laminae give irregularly fractured pieces a mottled appearance resembling basal Annville limestone.	3	14(
Dolomite, medium gray (N5), very finely megacrystalline, weathering light gray (N7).	1	14:
Limestone, medium light gray (N6), scattered euhedra, clusters and irregular laminae of dolomite weathering yellowish gray (5Y8/1); unit irregularly fractured.	2	142
Dolomite, medium dark gray (N4), with dark gray (N3) shaly layers, very finely megacrystalline; unit irregularly fractured.	18	140
Limestone, finely megacrystalline, laminated; poorly developed bedding cleavage.	2-1/2	122
Dolomite, medium dark gray (N4), very finely megacrystalline, parting into 2-foot layers; rusty-brown-weathering, stylolitic partings.	7	119-1/
Limestone, medium light gray (N6), very finely megacrystalline, laminated; scattered dolomite euhedra.	2	112-1/

	Thickness (feet) unit	total
Dolomite, medium light gray (N5), very finely megacrystalline; closely spaced, intersecting joint sets give blocky appearance to unit.	7-1/2	110-1/2
Limestone, medium gray (N5), very finely megacrystalline; numerous micro-folded laminae weathering yellowish gray (5Y8/1).	6	104
Dolomite, medium dark gray (N4), very finely megacrystalline to finely megacrystalline, laminated in part, parting into 1/2- to 1-foot layers; stylolitic partings; unit intersected by fault.	54	98
Limestone, medium light gray (N6), smoothly-fracturing cryptogranular with megacrystalline patches; dark-gray, corrugated laminae weathering yellowish gray (5Y8/1); disseminated dolomite euhedra.	1-1/2	44
Limestone, very light gray (N6), very finely megacrystalline; irregular fractures and intersecting joints.	1	42-1/2
Limestone, shaly, medium gray (N5), very finely megacrystalline; light-gray (N7), micro-folded laminae.	1/2	41-1/2
Dolomite, medium gray (N5), very finely megacrystalline to finely megacrystalline; transitional contacts.	1	41
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1- to 2-foot layers; 60 percent of surface area in upper 1 foot composed of interconnected lobes and lenses of yellowish-gray-weathering (5Y8/1) dolomite surrounding irregular lenses and patches of limestone.	5	40
Limestone, medium gray (N5), very finely megacrystalline; lensing laminae weathering yellowish gray (5Y8/1); scattered 1-mm. to 3-mm. leperditiid ostracode shells.	1	35

	Thickness (fee unit	tot
Dolomite, medium light gray (N6), very finely megacrystalline, weathering very light gray (N8); closely spaced intersecting joints.	2	3
Limestone, medium gray (N5), parting into 1/2-foot layers; stringers and lenses of yellowish-gray-weathering (5Y8/1) dolomite resembling "fucoids" increasing in proportion downward and surrounding numerous small leperditiid ostracode shells.	2-1/2	3
Dolomite, medium light gray (N6), finely megacrystalline, parting into 1/2- to 1-foot layers; closely spaced joints.	8	29-1,
Dolomite, medium gray (N5), very finely megacrystalline, irregularly fractured, parting into 1-foot layers.	3	21-1,
Dolomite, light gray (N3), very finely megacrystalline, weathers with pitted surface where 1/2-mm. to 1-mm. rounded, spherical to elongate calcite grains have selectively dissolved, parting into 3-inch layers.	4	18-1,
Dolomite, medium gray (N5), microcrystalline, weathering very light gray (N8), parting into 1- to 2-foot layers; indistinct laminae; closely-spaced joints giving unit blocky appearance.	11-1/2	14-1/
Limestone, medium light gray (N6), smoothly fracturing cryptogranular, parting into 1- to 2-foot layers; irregular dolomite laminae and mottling weathering yellowish gray (5Y8/1) and grading into solid dolomite bed in uppermost 6 inches.	3	3
Exposed thickness of Ontelaunee Formation		286-1/

On basis of measurements made in section no. 16, about 500 apparent stratigraphic are concealed to chert beds.

SECTION NUMBER 18

ohewa, Pennsylvania Date described: August, 1956

ocation and structure of section

Section No. 18 is located in abandoned quarry 0.15 mile west of ohewa, Pennsylvania, adjacent to northwest borough limits of Lebanon, ennsylvania, in Lebanon quadrangle at approximately 2.10 miles west f 76° 25' longitude and 1.90 miles north of 40° 20' latitude (Fig. 26).

Beds strike N85°E and dip 25°SE overturned. Traces of developed ock cleavage in limestones dip SE at angles less than dip of bedding, ndicating overturned beds. Lower part of section in the southeast orner of quarry is cut by at least one fault dipping 70° to 80° in a outherly direction. Direction and amount of displacement is unknown ut believed to be small.

Section begins at top of youngest bed in northern face of quarry nd continues southward along eastern wall to first bed of calcarenite. leasurements of beds below calcarentie are taken along the west wall nd up south face of quarry. Bedding thickness measurements made irectly with 8-foot tape.

ection description	Thickness (feet) unit	total
Annville Limestone		
Not exposed but indicated on map (Gray, 1952) on basis of extension from exposures in Cleona, 0.9 mile to west.	not measured	
Beekmantown Group Ontelaunee Formation		
Concealed. Traverse on map about 500 feet S5°E, bedding strike N85°E, dip 30°SE. Concealed beds described in section number 17.	250	767
Dolomite, medium gray (N5) to medium dark gray (N4), very finely megacrystalline, weathering yellowish gray (5Y8/1); numerous irregular fractures and calcite-filled veins.	2-1/2	517
Dolomite, medium dark gray (N4), very finely		

	Thickness (fee unit	tota
megacrystalline, weathering very light gray (N8), parting into 1/2-foot layers; indistinct regular parallel laminae; stylolitic seams.	2-1/2	514-1
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1-1/2	51
Dolomite, shaly in part, dark gray (N3) with thin irregular bands of medium gray (N5), thin shaly beds weathering yellowish brown and resembling bentonitic ash; dolomite bedding surfaces overlying and underlying shales are uneven and knobby.	1/2	510-1
Dolomite, medium gray (N5) to medium dark gray (N4), very finely megacrystalline, weathering very light gray (N8); indistinct parallel laminae.	3-1/2	51
Dolomite, medium light gray (N6), microcrystalline, weathering yellowish gray (5Y8/1).	1	506-1
Dolomite, medium gray (N5), very finely megacrystalline; numerous irregular fractures.	3	505-1
Dolomite, medium dark gray (N4), very finely megacrystalline; indistinct laminae.	1	502-1
Dolomite, medium gray (N5), very finely megacrystalline.	3	501-1
Dolomite, medium dark gray (N4), very finely megacrystalline; indistinct laminae.	2	498-1
Dolomite, medium gray (N5), microcrystalline, weathering light gray (N7).	2-1/2	496-1
Limestone, light gray (N7) with pinkish and brownish tinges, very finely megacrystalline, weathering very light gray (N8); irregular dark-gray (N3) streaks and laminae giving mottled appearance on irregularly-broken surface; unit gradational with dolomite below through zone of disseminated dolomite crystals;		

	Thickness (feet) unit	total
imperfect bedding cleavage.	1	494
Dolomite, medium gray (N5), very finely megacrystalline, weathering light gray (N7); regular parallel laminae, a number weathering inward with a fluted appearance to weathered surface.	4	493
Dolomite, medium dark gray (N4), very finely megacrystalline.	1	489
Dolomite, medium light gray (N6), microcrystalline, weathering yellowish gray (5Y8/1); regular parallel laminae.	3-1/2	488
Dolomite, medium dark gray (N4), very finely megacrystalline, weathering light gray (N7), regular parallel laminae, parting into 1-foot layers.	2-1/2	484-1/2
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1-foot layers.	3	482
Concealed. (Fault?)	10	479
Limestone, medium light gray (N6), very finely megacrystalline; irregular, dark-gray (N3) laminae; weathering surface fluted along imperfect bedding cleavage.	1	469
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), irregularly-banded by 1/4-inch silty laminae.	1-1/2	468
Limestone, medium light gray (N6), very finely megacrystalline; irregular, dark-gray (N3) laminae; 4 inches of disseminated dolomite euhedra at top; trace of cleavage plunging south at smaller angle than dip of bedding.	2	466-1/2
Dolomite, medium gray (N5), finely megacrystalline, weathering yellowish gray (5Y8/1); medium-dark-gray (N4), medium-megacrys-		

	Thickness (fee	
	unit	tota
talline zone at base; regular parallel laminae.	2-1/2	464-1
Concealed.	8	46
Dolomite, medium gray (N5), finely megacrystalline; zones with coarse doloruditic texture on weathered surface consisting of small, round to angular, elongate to equant, fragments weathering yellowish gray (5Y8/1) in a light-gray (N7) weathering matrix; stylolitic seams.	4	45
Limestone, medium light gray (N6), very finely megacrystalline; irregular, dark-gray (N3) laminae; disseminated and clustered dolomite euhedra.	1/2	45
Dolomite, medium gray (N5), very finely megacrystalline weathering yellowish gray (5Y8/1).	4	449-1
- Shatter zone. Fault with unknown displacement. -		
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 2-foot layers; several indistinct laminae.	6-1/2	445-1
Dolomite, medium gray (N5), very finely megacrystalline; numerous irregular fractures.	3	43
Dolomite, medium light gray (N6), very finely megacrystalline, fractured, parting into 2- to 3-foot layers.	6	43
Dolomite, medium gray (N5), very finely megacrystalline, fractured.	1-1/2	43
- Shatter zone: Fault? -		
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), fractured, parting into 4-foot layers; several indistinct laminae.	8	428-1/

	Thickness (feet) unit	total
Dolomite, medium dark gray (N4), very finely megacrystalline, weathering very light gray (N8), parting into 1-foot layers; regular parallel laminae.	3	420-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	5	417-1/2
Dolomite, medium dark gray (N4), very finely megacrystalline, weathering very light gray (N8); regular parallel laminae.	1	412-1/2
Limestone, medium light gray (N6) with dark-gray (N3) streaks, very finely megacrystalline; 1 foot of yellowish-gray-weathering (5Y8/1) dolomite lobes and lenses 1-1/2 feet above base; dolomite structures are distorted parallel to trace of rock cleavage; 1 foot dolomite bed 1/2 foot below top.	5	411-1/2
Dolomite, medium light gray (N6), finely megacrystalline, weathering yellowish gray (5Y8/1), fractured, parting into 3-foot layers.	6	406-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8), parting into 1-foot layers; several laminated beds.	8	400-1/2
Limestone, medium gray (N5), very finely megacrystalline, weathering very light gray (N7).	1	392-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering light gray (N7), laminated, parting into 1/2-foot layers.	4-1/2	391-1/2
Limestone, medium gray (N5), very finely megacrystalline, parting into 4-inch layers; irregular, discontinuous laminae and bands of dolomite weathering yellowish gray (5Y8/1).	5-1/2	387
Exposures; dolomite, medium gray (N5), very finely megacrystalline.	4	381-1/2

	Thickness (fee unit	tota
Limestone, light gray (N7), very finely megacrystalline, weathering very light gray (N8).	1	377-1
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8), parting into 1/2- to 1-foot layers.	18-1/2	376-1
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 3-foot layers.	8	35
Dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1- to 2-foot layers.	3-1/2	35
Dolomite, medium gray (N5), very finely megacrystalline, weathering light gray (N7), parting into 2-foot layers.	6	346-1
Dolomite, medium light gray (N6), very finely megacrystalline, parting into 4-foot layers; calcareous zone 2 feet from base containing cylindrical dolomite structures in a calcareous ground mass.	8-1/2	340-1
Limestone, medium gray (N5), very finely megacrystalline; 6-inch zone of dolomite mottling at base grading into dolomite unit below.	1-1/2	33
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 2-foot layers.	5-1/2	330-1
Concealed.	11	32
Limestone, medium gray (N5), very finely megacrystalline; very irregular interconnected lobes and lenses of dolomite covering about 30 percent of surface area.	1	31
Dolomite, medium gray (N5), very finely megacrystalline, weathering very light gray (N8),		

	Thickness (feet) unit	total
parting into irregular 2-inch layers.	4-1/2	313
Limestone, medium gray (N5), very finely megacrystalline with lenses of medium pelmatozoan calcarenite, parting into irregular 4- to 6-inch layers; lower 1 foot grades into underlying dolomite through zone of cylindrical dolomite structures.	2	308-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 2- to 3-foot layers; regular parallel laminae in upper 2 feet.	5-1/2	306-1/2
Limestone, medium gray (N5), very finely megacrystalline, weathering very light gray (N8); yellowish-gray-weathering (5Y8/1) lenses and irregular laminae distorted parallel to cleavage trace; cleavage N25°E, 21°SE.	2	301
Dolomite, medium gray (N5), very finely megacrystalline.	1	299
Limestone, medium gray (N5), very finely megacrystalline, weathering light gray (N7), parting into 2-1/2-foot layers; lower 2-1/2 feet contains sub-laminae of yellowish-gray-weathering (5Y8/1) dolomite; upper 2-1/2 feet contains dolomitic "fucoidal" structures on bedding surface.	5	298
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1).	1	293
- Fault, dipping 70° to 80° SE. -		
Limestone, medium gray (N5), very finely megacrystalline, contacts gradational through zones of dolomitic mottling.	3	292
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1-foot layers.	2	289

	Thickness (fee unit	tota
Poorly exposed limestone pinched between dolomite units.	1	28
Dolomite, medium light gray (N6) with medium gray (N5) interbeds, very finely megacrystalline to microcrystalline in part, weathering yellowish gray (5Y8/1), parting into 1- to 5-foot layers.	61	28
Concealed. Traverse map distance to chert float along railroad tracks 450 feet about S5°E; bedding strikes N85°E and dips 30°SE. Concealed strata included in section No. 16.	225	22
Total thickness of Ontelaunee Formation		76

SECTION NUMBER 19

Lebanon, Pennsylvania Date described: August, 1956

Location and structure of section

Uppermost exposures of composite section 19 are along southwest side of Cornwall railroad tracks in Lebanon, Pennsylvania about 0.45 mile from crossing with U.S. Route 422 in Lebanon quadrangle at approximately 0.05 mile west of 76° 25' longitude and 0.50 mile north of 40° 20' latitude (Fig. 26). Incomplete exposures continue along tracks southeastward to section in Cambrian limestone.

Bedding attitude variable with strikes ranging from N75° W to N85°W and dips from 18°SW to 40°SW overturned. Majority of beds dip between 20° and 30° SW overturned. Flowage structures are common in the limestones with development of imperfect bedding cleavage. Overturning of beds is inferred from order of superposition, overturned graded bedding, and rock cleavage with shallow dips to the south. Cleavage strikes N55°W and dips 18°SW.

Section description	Thickness (feet) unit	total
Epler Formation		
Dolomite with limestone interbeds increasing in proportion toward the top of the section; dolomite is medium gray (N5) to medium light gray (N6), very finely megacrystalline, laminated on a yellowish-gray-weathering (5Y8/1) surface; numerous thin laminae and bands of rounded quartz sand grains. Limestone occurs in 1-foot to 4-foot beds and is medium gray, very finely megacrystalline, with scattered dolomitic lobes, lenses and laminae distorted parallel to imperfect cleavage. Quartzose dolomite confined to 145 feet of section above lowermost limestone bed which is 25 feet above base of exposure. Thickness calculated from following traverse along line striking N30°W; 0 to 125 feet, bedding N84°W, 18°SW; 125 to 225 feet, bedding N75°W, 25°SE; 225 to 380 feet, bedding N75°W, 25°SE; 380 to 535 feet, bedding N75°W, 32°SW; 535 to 575 feet, bedding N55°W, 18°SW; 575 to 950 feet, bedding N78°W, 40°SW.	275-300	

	Thickness (fee unit	tot
Exposed thickness of Epler Formation	275-300	
Rickenbach Dolomite[1]		
Concealed. Traverse N32°W, 560 feet; bedding N84°W, 18°SW. Interval probably represents total thickness of Rickenbach dolomite which is exposed in scattered, small exposures through central and western Lebanon County.	130-140	
Probable thickness of Rickenbach Dolomite	130-140	
Stonehenge Limestone		
Exposures; limestone, medium gray (N5), very finely megacrystalline with lenses and zones of medium to coarsely megacrystalline (pelmatozoan?) material, weathering very light gray (N8) with several low-spired gastropods on weathered surface; irregularly banded by anastomosing, siliceous laminae and by dolomitic laminae. Traverse N32°W, 150 feet, bedding N80°E, 32°SW.	50-75	
Exposed thickness of Stonehenge Limestone	50-75	
Concealed. Traverse N32°W, 1325 feet; bedding N75°E, 40°SE.	800-825	
Cambrian System		
Conococheague Formation		
Dolomite and interbedded limestone; abundant quartz sand; oolitic chert; exposed but not measured.		

1. Although identified in section, the Rickenbach Dolomite is not mappable here or west of Lebanon (Geologic Map of Pennsylvania, 1960).

SECTION NUMBER 20

Palmyra, Pennsylvania

Date described: August, 1956
Date sampled: July, 1957

Location and structure of section

Section No. 20 is located in east face of eastermost quarry of H. E. Millard Co., 0.70 mile north of the square in Palmyra, Lebanon County, Pennsylvania, in south central part of Hummelstown quadrangle at approximately 1.15 miles south of 40° 20' latitude and 1.0 mile west of 76° 35' longitude (Fig. 26). Exposure currently being worked for industrial purposes.

Beds strike N60°E and dip 55°SE overturned. Overturning indicated by younger Annville limestone underlying the dolomite.

Section description	Thickness (feet) unit	total
Annville Limestone		
Limestone, medium light gray (N6) with dark-gray (N3) streaks and mottling at base, megacrystalline, laminated in part.	not measured	
Beekmantown Group Ontelaunee Formation		
Dolomite, medium dark gray (N4) to dark gray (N3), very finely megacrystalline, parting into 1- to 2-foot layers; black, soft, carbonaceous shale between massive dolomite beds in lower portion; numerous stylolitic partings.	27	97
Dolomite, partly concealed, medium dark gray (N4), very finely megacrystalline, laminated, deeply weathered light gray (N7); styolitic partings; black, carbonaceous shale layers; float at base of unit contains mud-crack casts surrounded by particles of carbonaceous shale.	16	70
Dolomite, medium dark gray (N4), very finely megacrystalline, parting into 1/2-foot layers; regular parallel laminae; weathering deep light gray (N7).	6	54

	Thickness (feet) unit	total
Dolomite, medium dark gray (N4), very finely megacrystalline, weathering light gray (N7); regular parallel laminae; styolitic seams.	8	48
Dolomite, medium gray (N5), finely megacrystalline, parting into 1-foot layers; irregular, sparry carbonate-filled fractures.	4	40
Limestone, highly dolomitic, medium gray (N5), cryptogranular, parting into 2-foot layers; much medium-light-gray (N6), finely megacrystalline dolomite in sub-banded distribution of lobes and lenses and cylindrical structures; small cycles beginning with dolomite mottling and grading upward through sub-banded distribution into zones consisting of 90 percent dolomite are apparent; one or two dolomitized low-spired gastropods; elongate, subangular fragments of laminated limestone in lower part.	4	36
Dolomite, medium dark gray (N4), very finely megacrystalline; transitional contact with overlying unit through 1-inch to 7-inch zone of "fucoidal" mottling.	1-1/2	32
Exposures, limestone, medium gray (N5), cryptogranular; medium-light-gray (N6) lobes and lenses of dolomite.	3	30-1/2
Dolomite, medium dark gray (N4), very finely megacrystalline, parting into 1- to 2-foot layers; laminated in part; layers of carbonaceous shale.	20-1/2	27-1/2
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 4-inch to 1-foot layers; regular parallel laminae.	6	7
Dolomite, medium dark gray (N4), very finely megacrystalline, weathering light gray (N7).	1	1
Exposed thickness of uppermost Ontelaunee Formation		97

SECTION NUMBER 21

Hummelstown, Pennsylvania (No. 1) Date described: August, 1956

Location and structure of section

Section No. 21 is exposed in northeast face of abandoned quarry on north bank of Swatara Creek 0.35 mile north of center square in Hummelstown, Dauphin County, Pennsylvania, in Hummelstown quadrangle at approximately 2.20 miles east of 76° 45' longitude and 1.45 miles north of 40° 15' latitude (Fig. 26).

Bedding strikes N70°W and dips 25°SW overturned. Several shattered zones with slickensided blocks of dolomite visible in northern corner of quarry. Prominent vertical fault strikes N5°E; direction of slickensides indicates strike slip movement.

Section measurement begins at fault on northeastern face and continues southeastward along the face to end of exposure. Cherty bed near top of exposures may be western extension of cherty zone in Ontelaunee dolomite of Lebanon and Berks Counties. All thickness measurements made with an 8-foot tape.

Section description	Thickness (feet) unit	total
Annville Limestone		
No measureable exposures. Believed to be less than 75 feet thick (Geyer, pers. comm.).		
Beekmantown Group		
Ontelaunee Formation		
Exposures in trench dug for pipeline; medium-dark gray (N4), megacrystalline dolomite. Estimated thickness of exposure.	25	606-1/2
Concealed. Traverse on aerial photo, 1050 feet about S20°W; bedding strikes N70°W and dips 30°SW overturned.	525	581-1/2
- Fault -		

	Thickness (feet) unit	total
Dolomite, medium light gray (N6), microcrystalline to very finely megacrystalline.	7	56-1/2
Dolomite, medium light gray (N6), finely to medium megacrystalline.	1	49-1/2
Dolomite, medium light gray (N6), very finely megacrystalline, parting into poorly-developed 2-foot layers; well developed joints and irregular fractures.	7-1/2	48-1/2
Dolomite, medium gray (N5), very finely megacrystalline.	12	41
Dolomite, medium gray (N5), very finely megacrystalline; regular parallel laminae.	1-1/2	29
Dolomite, medium light gray (N6), very finely megacrystalline, weathering light yellowish gray (5Y8/1), parting 5-1/2 feet above base; indistinct laminae; 6-inch zone of fault breccia adjacent to fault surface; fault strikes N80° W and dips 30°SW; direction of slickensides indicates oblique movement along fault.	8-1/2	27-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1); regular parallel laminae.	1-1/2	19
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1-1/2-foot layers; stylolitic partings. in upper 2 feet.	7	17-1/2
Cherty dolomite layer, dark gray (N3), tends to split into 1-inch beds; tightly packed ostracode shells; varies in thickness from 3 inches to 1 foot.	1	10-1/2
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish gray (5Y8/1),		

	Thickness (feet) unit	total
parting into 1- to 3-1/2-foot layers.	9-1/2	9-1/2
Exposed thickness of Ontelaunee Formation		331-1/2
Total estimated thickness of Ontelaunee Formation		606-1/2

SECTION NUMBER 22

Hummelstown, Pennsylvania (No. 2) Date described: June, 1955
April, 1957

Location and structure of section

Section No. 22 is exposed along southern bank of Swatara Creek 1.75 miles southwest of square in Hummelstown, Dauphin County, Pennsylvania, in southwestern part of Hummelstown quadrangle at approximately 0.80 mile east of 76° 45' longitude and on 40° 15' latitude (Fig. 26). Youngest exposures are west of road that crosses Swatara Creek through covered bridge; exposure continues stratigraphically downward along Swatara Creek west of quarry opening. Thickness of beds stratigraphically above Ontelaunee dolomite from Gray et al., 1954. Description and thickness of beds stratigraphically above Beekmantown have recently been published by Prouty, 1960.

Beds strike N60°E and dip 30°SE overturned. Overturning is indicated by stratigraphic sequence. Oldest beds are exposed in core of shallow synclinal flexure.

Section description	Thickness (feet) unit	total
Middle Ordovician Series		
Martinsburg Shale		
Shale, gray, deeply weathered, foliated.	not measured	
- Contact gradational through zone with alternation of layers that effervesce freely in dilute HCl and layers that show no reaction with acid. -		
Hershey Limestone		
Limestone, black, slaty cleaved, deeply weathered; indistinct conglomerate zone at base with angular dolomite pebbles in a dark, shaly, deeply weathered limestone matrix.		
Total estimated thickness of Hershey Limestone		438
Myerstown Limestone		
Limestone, thin-bedded to shaly, dark gray, very finely megacrystalline, graphitic, laminated in		

	Thickness (feet) unit	total
part.	52	52
Total thickness of Myerstown Limestone		52
Annville Limestone		
Limestone, thick-bedded, medium gray (N5) to light gray (N7) with dark-gray (N3) stringers, laminae and mottling especially in basal portion, very finely to finely megacrystalline, pure.	77.6	77.6
Total thickness of Annville Limestone		77.6
- Contact with Beekmantown dolomite is sharp showing drag of overlying dolomite beds near top of west quarry face. Stratigraphic displacement unknown but believed to be small. -		
Lower Ordovician Series Beekmantown Group Ontelaunee Formation		
Dolomite, medium gray (N5) to medium dark gray (N4), very finely to finely megacrystalline, deeply weathered medium light gray (N6), parting into 1- to 6-foot layers; fresh blocks in quarry medium dark gray and dark gray (N3); thin layers of carbonaceous shale common.	40	123
Limestone, medium gray (N5), very finely megacrystalline, scattered nodules of black (N1) chert.	1/2	83
Dolomite, poorly exposed, medium gray (N5), very finely megacrystalline, weathering very light gray (N8).	30	82-1/2
Dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline, microcrystalline in part; partings not recorded.	32	52-1/2
Limestone, medium light gray (N6), with dark-gray (N3) streaks, very finely megacrystalline; imperfect bedding cleavage.	1/2	20-1/2

	Thickness (feet) unit	total
Dolomite (parting not recorded) and several limestone interbeds, poorly exposed; dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline; several elongate dark chert nodules in limestone beds.	20	20
Measured thickness of Ontelaunee Formation		123

SECTION NUMBER 23

Hummelstown, Pennsylvania (No. 3) Date described: July, 1954

Location and structure of section

Section No. 23 is located in cut along traffic circle on U.S. Route 422, 1/4 mile south of Hummelstown, Dauphin County, Pennsylvania in southwestern part of Hummelstown quadrangle at approximately 0.85 mile north of 40° 15' latitude and 2.2 miles west of 76° 40' longitude (Fig. 26). Upper 100 feet or so of beds are exposed north of quarry across highway to the northeast.

Beds strike N25°E and dip 25° SE overturned. Overturning implied on basis of order of superposition with the younger Ontelaunee dolomite outcropping to the northwest and structurally underlying Epler limestone.

Section description	Thickness (feet) unit	total
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee Dolomite		
Unmeasured exposures of dolomite on both sides of Reading Company's railroad tracks and in field to south of tracks.	not measured	
Epler Formation		
Concealed to uppermost exposures in quarry. Estimated 100 to 200 stratigraphic feet.	150	431
Limestone, medium gray (N5), calcarenitic, parting into thin irregular beds; irregular dolomitic and siliceous laminae; several dolomitized, low-spired, dextrally-coiled gastropods on bedding surfaces.	100	281
- Following exposures in road cut southwest of quarry. -		
Limestone, alternating medium gray (N5) to medium light gray (N6), roughly-fracturing cryptogranular with several smoothly-fracturing beds, parting into regular 2-inch to 1-		

	Thickness (feet) unit	total
foot layers; lenses and thin beds of pelmatozoan calcarenite very common; dark, siliceous laminae in most beds; section described in detail but summarized here owing to rather uniform lithology.	181	181
Measured thickness of Epler Formation		431
Concealed to Triassic beds.	not measured	

SECTION NUMBER 24

:ummelstown, Pennsylvania (No. 4) Date described: July, 1956

,ocation and structure of section

Section 24a is located in southwestern part of Hummelstown quadangle approximately 1.3 miles north of 40° 15' latitude and 0.25 mile ast of 76° 45' longitude (Fig. 26). Exposures are along the south side of ıe Pennsylvania Railroad tracks 2 miles west of the square in Hummelsɔwn.

The beds strike about N40°E and dip 10°SE. A small anticlinal ιexure is exposed about 75 feet west of the contact of the shaly beds.

An additional exposure of the contact (24b, Fig. 26) was exposed uring recent highway construction along U.S. Route 422 about 1/2 mile o the west of section 24a and 7 miles east of the center of Harrisburg, ut is now covered. Highway exposures are apparently on the southern lank of an anticline exposing the Ontelaunee in this area and section 4a on the northern flank, although this may well be an oversimplified nterpretation of the geologic structure in the immediate area of the ections. In contrast to section 24a where the contact is apparently with Iershey limestone or calcareous Martinsburg shale, the highway con-struction exposed a contact with noncalcareous shale. The following lescription is of section 24a.

;ection description	Thickness (feet) unit	total
Middle Ordovician Series		
Martinsburg shale or Hershey limestone		
Limestone, argillaceous, silty, dark, breaking in thin, platy fragments, weathering brownish and resembling Hershey shale in section no. 22, strongly effervescent in cold, dilute HCl. Estimated thickness of exposure.	25	25
Lower Ordovician Series (?)		
Ontelaunee Formation		
Dolomite, highly fractured and recemented, medium light gray, very finely to finely megacrystalline, weathering yellowish gray; thin interbeds of pure, megacrystalline,		

	Thickness (fee	
	unit	tota
cherty limestone with imperfect bedding cleavage. Estimated thickness in crest of small anticline.	25-50	

Note: Exposed about 300 yards to the southwest in a quarry, drainage ditch and road cut is a nearly horizontal body of 25 to 50 feet of light-gray, megacrystalline, pure limestone of Annville lithology but with chert nodules. This unit is believed to underlie the dolomite body exposed in section 24a and is apparently the body exposed at places to the west along U.S. Route 422.

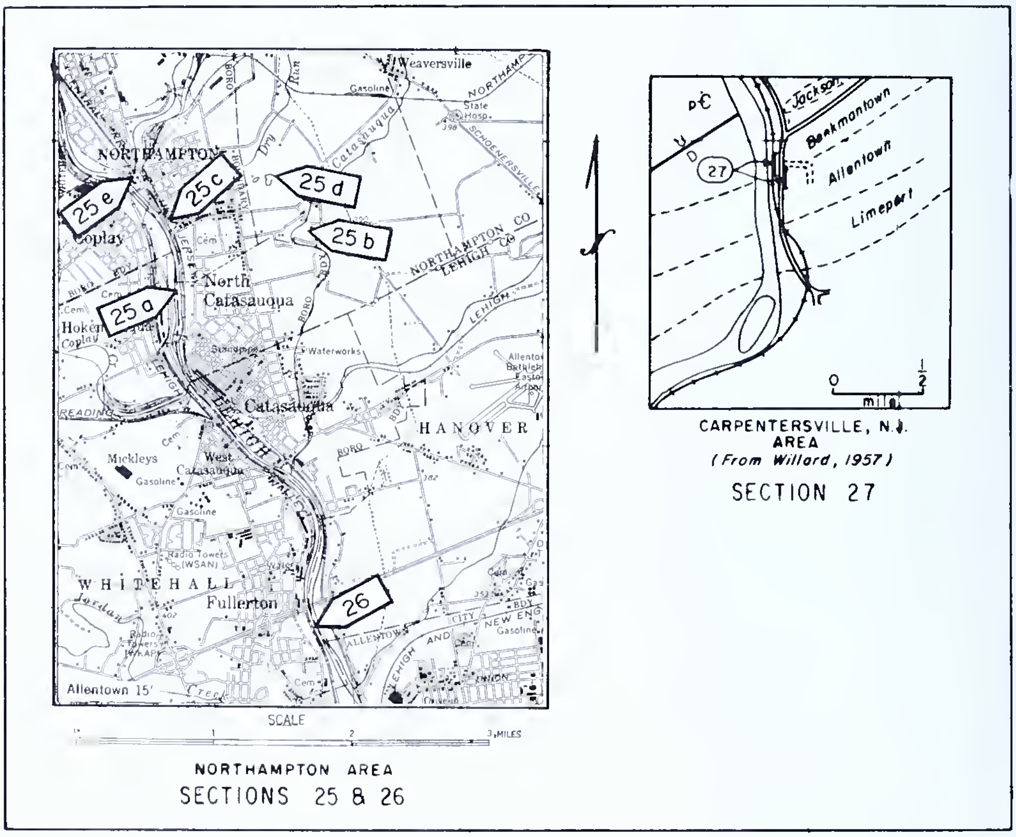


Figure 27. Location of sections 25-27

SECTION NUMBER 25

orthampton, Pennsylvania Date described: August, 1956
April, 1957

ocation and structure of section

Lowest exposures of composite section no. 25, Fig. 27, are along and R of New Jersey railroad tracks on east bank of Lehigh River, .88 mile south of center of southern portion of Northampton, Northampton, County, Pennsylvania, in west central part of Allentown quadrangle pproximately 0.05 mile south of 40° 40' latitude and 0.90 mile east of 5° 30' longitude. Exposure continues northward and stratigraphically pward through a series of small quarries (25c, 25d, Fig. 27) to conact with Jacksonburg limestone in Northampton. The uppermost described trata are in bed of small stream flowing through center of Northampton 25e, Fig. 27).

Oldest beds are essentially horizontal, exposed along tracks and quarries (25a, Fig. 27) in crest of broad anticline with gently dipping mbs. Uppermost beds exposed along tracks strike N70°E and dip 48°NW. 'artially concealed folds in upper beds are numerous, rendering accurate easurement impossible. Uppermost strata in stream bed strike N90°E nd dip 65°SE overturned. Cleavage in the latter beds strikes N80°E to I90°E and dips 40°SE. A similar attitude is observed in a small quarry n Jacksonburg limestone 0.30 mile to the northeast of the stream cut. 'he Beekmantown-Jacksonburg contact is not visible and is interpreted s overturned on basis of dip and strike readings. Miller, et al. (1939) ndicate a non-faulted contact at this place on the geologic map of Iorthampton County.

ection description	Thickness (feet) unit	total
Middle Ordovician Series		
Jacksonburg Limestone		
Limestone (shaly partings), dark, megacrystalline; slaty cleavage. Thickness from R. L. Miller (in B. L. Miller, 1939).		700
- unconformity -		
Lower Ordovician Series		
Beekmantown Group		
Ontelaunee and Epler Formations (?)		

	Thickness (fee	
	unit	tot
Concealed. Estimated from interval between exposed Jacksonburg limestone and first exposure of Beekmantown dolomite in Northampton. Traverse about 250 feet due south. Bedding strikes N90°E and dips 65°SE overturned.	225	1563()
Dolomite, medium gray (N5) to medium dark gray (N4), very finely megacrystalline, weathering medium light gray (N6), parting into 1- to 4-foot layers; several thin limestones with imperfect bedding cleavage and with fracture cleavage inclined to bedding. Bedding N90°E, 65°SE overturned. Fracture cleavage strikes N80°E to N90°E and dips 40°SE.	75	1338()
Concealed. Traverse S20°E, 1625 feet. Beds near middle of concealed interval are exposed in several quarries to northeast (d, Fig. 27); exposure in these quarries is largely of megacrystalline limestone. Measurement of the exact thickness of limestone unit is not possible, however a maximum of 200 feet of limestone with several thin dolomites is estimated. These beds are involved in folds and faults in all of the quarries where exposed. The bedding strike is generally N50°E and the dip varies between 65°SE overturned and 30°NW. Fracture cleavage in the limestone dips 30°SE to 40°SE. Concealed interval computed on basis of bedding strike of N50°E and dip of 30°NW. Probable true stratigraphic thickness less than 700 feet.	700(?)	1263()
Exposures, dolomite, medium gray (N5) to medium dark gray (N4), finely to coarsely megacrystalline; indistinct laminae in several beds; about 30 percent exposure. Traverse S30°E, 300 feet, bedding N65°E, 40°NW.	190	56
Concealed. Traverse S20°E, 385 feet. Bedding N70°E, 50°NW.	300	37

	Thickness (feet) unit	total
Limestone, medium gray (N5), finely megacrystalline, rounded medium quartz sand.	5	73
Dolomite, medium gray (N5), medium megacrystalline, indistinct laminae, parting into 1/2- to 2-foot layers.	30	68
Exposures; dolomite, medium gray (N5), finely megacrystalline.	20	38
Limestone, medium gray (N5), finely megacrystalline, parting into 5-foot layers; black (N1)-weathering, micro-folded siliceous laminae.	10	18
Dolomite, medium gray (N5), very finely megacrystalline, wavy, irregular laminae; boudinaged.	2-1/2	8
Limestone, medium gray (N5), very finely megacrystalline; black-weathering (N1), micro-folded laminae.	5-1/2	5-1/2
Total thickness of Ontelaunee and Epler Formations (?)		1563(?)

Rickenbach Formation (?)

	unit	total
Concealed. Traverse N10°W, 385 feet; bedding N70°E, 15°NW.	100	502
Dolomite, medium gray (N5), very finely megacrystalline to finely megacrystalline, parting into 3-inch to 3-foot layers; irregular, wavy laminae, weathering black (N1).	30	402
Dolomite, medium light gray (N6), very finely megacrystalline, weathering yellowish gray (5Y8/1), parting into 1-foot layers.	3-1/2	372
Dolomite, medium gray (N5), finely megacrystalline, parting into 2-foot layers; irregular, wavy, black-weathering (N1), siliceous laminae separating bands of thinner, cross-bedded quartzose laminae.	8	368-1/2

	Thickness (feet) unit	total
Exposures; dolomite, medium gray (N5), very finely megacrystalline, laminated; large irregular dark-chert masses at base.	8	360-1
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1-foot layers; regular parallel, silty laminae and upright silty cross-bedding; 6-inches of shaly dolomite in middle of unit.	19	352-1
Dolomite, medium gray (N5), finely megacrystalline, parting into 1/2- to 1-foot layers; conspicuous, regular parallel laminae; 4 evenly spaced zones of black chert nodules in uppermost 3 feet; zones of small to medium size, angular to subangular cobbles of dolomite and fragments of chert restricted to bedding.	6-1/2	333-1
Dolomite, medium gray (N5), very finely megacrystalline, parting into 1-foot layers; wavy laminae.	2	32
Dolomite, medium gray (N5), finely megacrystalline.	1	32
Dolomite, medium gray (N5), very finely megacrystalline; stringers and bands of rounded medium quartz sand with upright graded bedding.	2	32
Dolomite, medium gray (N5), finely megacrystalline; wavy, irregular dark laminae; elongate masses and nodules of black chert (N1).	1-1/2	32
Dolomite, medium gray (N5), with medium-light-gray (N6) splotches, finely megacrystalline, parting into 2-foot layers; conspicuous laminae.	7	320-1
Dolomite, medium dark gray (N4), finely megacrystalline with several medium-megacrystalline beds, parting into 1-foot layers; several wavy, irregular dark laminae and streaks; irregular,		

	Thickness (feet) unit	total
white-carbonate-filled microfractures.	7-1/2	313-1/2
Dolomite, medium gray, very finely megacrystalline.	1	306
Concealed to small quarries (b, Fig. 27); estimated at no more than 100 stratigraphic feet and probably somewhat less.	100	305
Dolomite, medium gray (N5) to medium dark gray (N4), medium megacrystalline, parting in 2- to 5-foot layers.	45	205
Concealed to contact with Allentown formation as estimated from exposures across river at Fullerton in which distance from lower limestone bed in Beekmantown to upper Allentown formation is about 500 feet. Contact apparently not exposed on east side of river.	160	160
Total estimated thickness of Rickenbach Formation (?)		502
Total estimated thickness of Beekmantown Group (probably maximum value)		2065

SECTION NUMBER 26

Fullerton, Pennsylvania — Date described: July, 1956; November, 1957

Location and structure of section

Section No. 26, Fig. 27, is in railroad cut along west side of Lehigh River immediately southeast of Fullerton, Pennsylvania, in west central part of Allentown quadrangle at approximately 1.85 miles east of 75° 30' longitude and 2.60 miles south of 40° 40' latitude. Exposure begins in cut immediately adjacent to tracks south of railroad signal bridge and continues upward stratigraphically through quarry opening situated about 50 feet from tracks.

Beds in north end of section strike N60°E and dip 60°SE and in south end of section N85°E and 50°SE. Beds overturned on basis of fracture cleavage (traces plunge 25°S) and overturned cryptozoon structures in south end of section.

Measurements by pace and compass traverse. Traverse begins a stratigraphic base of cryptozoon beds at south end of section. Traverse distance to stratigraphic top of each unit given in parentheses at end of unit description. Traverse N30°W, 0 to 345 feet, bedding N85°E, 50°SE; N30°W, 345 to 740 feet, bedding N70°E, 45°SE; N30°W, 740 to 1675 feet, bedding N60°E, 60°SE.

Section description	Thickness (fee unit	tota
Lower Ordovician Series Beekmantown Group Epler Formation (?)		
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish, laminated; thin interbeds of very finely megacrystalline, pure limestone. Exposures poor. (1675 feet).	174	45
Unit characterized by about 70 percent dolomite, 30 percent limestone of lithology similar to overlying unit. About 80 percent exposed. (1475 feet).	282	28.
Total measured thickness of Epler Formation (?)		45

	Thickness (feet) unit	total
Rickenbach Dolomite (?)		
Dolomite, medium gray (N5) to medium light gray (N6), finely megacrystalline, heavily coated exposures. (1150 feet).	47	486
Concealed; exposures of dolomite in lower 50 feet of traverse. (1095 feet).	115	439
Concealed. (945 feet).	67	324
- cycles -		
Dolomite; alternating beds of very finely to finely megacrystalline, medium-light-gray (N6), thinly laminated dolomite with quartzose laminae and bands; and of apparently structureless medium-gray (N5) to medium-dark-gray (N4), medium-megacrystalline dolomite; unit represents typical interbedding of fine-grained, quartzose, laminated lithology and coarser-grained, structureless lithology. (860 feet).	69	257
- cycle -		
Dolomite, medium gray (N5) to medium light gray (N6), thinly laminated to -banded; quartzose laminae and bands common. (770 feet).	23	188
Dolomite, medium gray (N5) to medium dark gray (N4), medium to coarsely megacrystalline; rock laced with gash fractures, weathers with massive irregular appearance. (740 feet).	63	165
Following descriptions in railroad cut		
Dolomite, of lithology in underlying, stratigraphically younger unit; dark chert masses of irregular shape. (650 feet).	24	102
- cycles -		
Dolomite, medium gray (N5), thinly laminated to		

	Thickness (fee	
	unit	tot
-banded with shaly appearance in places; parting in general into 3- to 6-inch layers; quartzose laminae and bands. (615 feet).	46	7
Dolomite, alternating very finely megacrystalline, thinly laminated to -banded, yellowish-weathering, quartzose-laminated dolomite and structureless, gash-veined, medium-megacrystalline dolomite. (545 feet).	32	3
Total measured thickness of Rickenbach Formation (?)		48

Upper Cambrian Series
Allentown Dolomite

- cycles -

Dolomite, alternating thinly laminated, yellowish-weathering, very finely megacrystalline dolomite and medium-megacrystalline, structureless dolomite weathering neutral gray; cryptozoon stromatolites at top of unit associated with flat-pebble conglomerate beds. (495 feet)	68	33
Dolomite, medium gray (N5), thinly laminated, quartzose; conglomerate; parting into thin and shaly layers, weathering yellowish; few beds of structureless, coarser-grained dolomite. (390 feet).	29	27
Dolomite, medium gray (N5) to medium dark gray (N4), medium megacrystalline, parting into 1- to 2-foot indistinct layers. (345 feet).	13	24

Dolomite, medium gray (N5) to medium light gray (N6), very finely megacrystalline, thinly laminated with quartzose laminae and bands; dark chert nodules and stringers restricted to bedding, shaly layers common, top of unit at highly quartzose zone; a number of small diastemic surfaces overlain by quartzose conglomerates; indistinct beds of thinly laminated strom-

	Thickness (feet) unit	total
atolites, cryptozoon type in bottom bed. (330 feet).	70	229
Dolomite, similar to underlying, stratigraphically younger unit with fewer shaly zones, more conglomerate and quartz sand; beds of light- and dark-weathering bands common; several beds of structureless, coarser-grained dolomite. (230 feet).	125	159
Dolomite, finely megacrystalline, thinly laminated, large and small stromatolites, cryptozoon type prolific in thinly laminated beds; several darker, coarser grained beds. (50 feet).	34	34
Total measured thickness of Allentown Formation (approximate)		339

SECTION NUMBER 27

Carpentersville, New Jersey Date described: July, 19
November, 195

Location and structure of section

Composite section No. 27, Fig. 27, is exposed along eastern sid of Delaware River south of Carpentersville, New Jersey, in west centr part of Easton quadrangle beginning at approximately 1.05 miles west 75° 10' longitude and 2.35 miles south of 40° 41' latitude.

Beds strike N45°E to N55°E and dip 60°SE to 75°SE, overturned Overturning of beds is indicated by stratigraphic sequence, fracture cleavage striking N80°E and dipping 40°SE, convexly downward strom-atolites, cryptozoon type, and inverted graded bedding in several of th quartzose beds.

Traverse begins at top of youngest stratum in river bed opposite Carpentersville and extends stratigraphically downward to beds exposec in road cut above level of river. Traverse of each individual unit S40°E, aggregating 655 traverse feet (general line of traverse S5°E), bedding N50°E, 75°SE overturned; traverse offset N50°E about 75 feet; traverse S10°E, 655 to 860 feet to beginning of road cut, bedding N55°I 75°SE overturned. Beginning in road cut; beds measured perpendicular to bedding stratigraphically downward through a prominent ledge of massive dolomite projecting into the southern one-quarter of the third quarry south of Carpentersville and the second quarry situated immedia adjacent to the road.

Traverse distance from the top of the youngest bed to the base of each descriptive unit is given in parentheses after each unit description

Section description	Thickness (fee) unit	tot
Middle Ordovician Series		
Jacksonburg Limestone		
Float and small outcrop of dark, shaly, mega-crystalline limestone. Noted in sketch map of Willard (1955, p. 822).	not measurec	
Lower Ordovician Series		
Beekmantown Group		

	Thickness (feet) unit	total
Concealed. Estimated from map (scale 1:31680) from extension of exposure of Jacksonburg on top of hill to upper exposures measured in river bed. Traverse S40°E about 700 feet, bedding N50°E, 70°SE, overturned. Estimate only.		658
pler Formation (?)		
Limestone, slowly and evenly effervescent, medium light gray (N6), very finely megacrystalline to cryptogranular, pure, dolomitic- and siliceous-laminated and -mottled; interbeds of very finely megacrystalline, medium-light-gray, laminated dolomite; nodular and bedded cherts. (75 feet).	72	139
Dolomite, cherty-mottled, poorly exposed. (105 feet).	29	67
Dolomite, cherty, pure limestones in upper portion. (145 feet).	38	38
Measured thickness of Epler Formation (?)		139
ickenbach Dolomite (?)		
Dolomite, breccia; composed of subangular, laminated blocks of dolomite in cherty, dolomitic matrix, majority of dolomite medium to coarsely megacrystalline; blocks arranged in random fashion; poorly exposed. (185 feet).	38	818
Dolomite, medium light gray (N6), very finely megacrystalline, thinly laminated. (205 feet).	19	780
Concealed. (265 feet).	58	761
Dolomite, slightly effervescent in places, medium megacrystalline, weathered surface with darker siliceous mottling in subreticulate disposition grading laterally into chert beds at some horizons; some mottling resembles "fucoidal"		

	Thickness (fe[illegible]) unit	to[illegible]
lobes and lenses; dark chert nodules and stringers parallel bedding in lower beds. (320 feet).	53	7[illegible]
Dolomite, breccia; angular to subrounded boulders to cobbles of very finely megacrystalline, laminated dolomite in cherty, coarse-grained matrix. (405 feet).	78	6[illegible]
Concealed. (450 feet).	43	5[illegible]
Dolomite breccia, similar to above, several rounded boulders of thinly laminated dolomite; majority of fragments subangular to angular. (535 feet).	82	5[illegible]
Concealed. (595 feet).	58	47[illegible]
Dolomite breccia similar to above, several well-rounded cobbles and boulders. (655 feet).	58	3[illegible]
Following section along tracks and in quarry above stream bed.		
Dolomite, medium gray (N5) to medium dark gray (N4), finely to medium megacrystalline, weathering neutral gray with "gritty" to "vuggy" surface, laced with tapering gash fractures; disseminated micro-fractures filled with sparry dolomite are characteristic; lower beds calcitic-mottled to -banded with ridged and pitted weathering surface; exposures heavily coated. (740 feet).	81	31[illegible]
Concealed. (860 feet).	95	20[illegible]
Following exposures in road cut.		
Dolomite, medium gray (N5), finely megacrystalline, structureless, poorly exposed.	6	15[illegible]
Dolomite, medium gray (N5) very finely megacrystalline, laminated; black chert (N1) at base.	9-1/2	1[illegible]

	Thickness (feet) unit	total
Dolomite, very finely megacrystalline, structureless.	4-1/2	139-1/2
Dolomite, very finely megacrystalline, thinly laminated, shaly-weathering appearance; outcrop coated.	6	135
Dolomite, finely megacrystalline, styolitic; outcrop coated.	6	129
Dolomite, medium gray (N5) to medium dark gray (N4), laminated to banded, very finely to finely megacrystalline.	6	123
- cycle -		
Dolomite, medium gray (N5), very finely to finely megacrystalline; thin, silty laminae; irregular dark chert nodules and masses.	11-1/2	117
Dolomite, medium gray (N5) to medium dark gray (N4), medium megacrystalline, structureless.	3	105-1/2
-cycle -		
Dolomite, medium gray (N5), very finely megacrystalline, weathering yellowish; thin silty laminae; chert at top.	9	102-1/2
Dolomite, medium dark gray (N4), finely megacrystalline; laced with white gash veins; lower contact indistinct.	4-1/2	93-1/2
- cycle -		
Dolomite, medium light gray, very finely megacrystalline, weathering yellowish; chert at top and middle; unit gradational into unit below; upper 5 to 6 feet thinly laminated.	11	89
Dolomite, medium gray (N5) to medium dark gray (N4), finely megacrystalline with medium-megacrystalline zones extensively gash-veined in some beds.	12-1/2	78

	Thickness (fee[t]) unit	tot[al]
- cycle, quartzose -		
Dolomite, very finely megacrystalline, thinly laminated, quartzose bands; weathering yellowish.	3	10
Dolomite, medium gray (N5), medium megacrystalline, thin irregular to discontinuous styolitic laminae.	8 -1/2	10
- cycle, quartzose -		
Dolomite, medium light gray, thinly laminated to -banded; alternating light- and dark-colored layers; numerous zones of quartz sand; beds of medium-megacrystalline, structureless dolomite 35 feet from base.	38-1/2	95-1
Dolomite, medium gray (N5), medium megacrystalline, structureless, gash-veined.	6	5
- cycle, quartzose -		
Dolomite, medium gray (N5), very finely megacrystalline, laminated; numerous quartzose bands.	2	5
Dolomite, medium gray, medium megacrystalline.	1	4
- cycle, quartzose -		
Dolomite, fine-grained, banded to laminated, much quartz sand, 1 foot bed of dolomitic quartzite at base. Traverse S50°W, 75 feet; N45°E, 62°SE.	42	4
Dolomite, medium dark gray, medium megacrystalline, gash-veined, massive and structureless.	6	
Measured thickness of Allentown Dolomite		13

Description of section stopped here; exposures continue in Allentown beds.

APPENDIX III

GLOSSARY OF TERMS

The following definitions are given only to show the usage of the ted terms in this text. The definitions, therefore, should not be con- lered complete or historically correct.

uminate	"Referred to an acute apex whose sides are somewhat concave and taper to a protracted point" (Lawrence, p. 737, 1951 in Glossary of Geology and Related Sciences, 1957).
gal limestone	limestone containing megascopically visible laminated structures or stromatolites attributed to the work of algae.
locthonous conglomerate	conglomerate in which the conglomerate-sized fragments were derived from outside the basin of deposition.
gular	"All edges of a grain are sharp" (Krynine, 1948, p. 142).
hedral	referred to authigenic crystals that do not possess a single well-formed crystal face in the plane of the thin section.
erture	opening of shell at outer end of living chamber
orescent structures	delicate sedimentary or early-diagenetic structures of highly variable morphology in some Beekmantown dolomites that have a plant-like form in a few places.
enaceous quartzose)	referred to limestone or dolomite that contains megascopically visible sand grains of quartz.
gillaceous	referred to limestone containing visible amounts of clay-sized silicate minerals.
ymmetrical cycle	a limestone-dolomite-limestone cycle in which one of the limestone-dolomite contacts is transitional through a zone of calcite-dolomite mottling.

authigenic	referred to a mineral believed to be in the place and position where it originally formed.
axial segment (trilobite)	"Transverse division of axis of thorax or pygidium of a trilobite" (Moore, Lalicker & Fisher, 1952, Invertebrate Fossils, p. 477).
band	sedimentary stratum at least 1 cm. thick and generally, in practice, less than seve centimeters thick.
bedded	referred to thickness between partings alo the bedding planes in outcrop section descriptions.
bioclastic	referred to limestone composed in considerable part of megascopically visible fossil fragments that are usually broken or worn or have become dissociated. Als referred to the fossil debris itself.
brachiophore	"In brachiopods, short, generally stout projections from beak region...for attachment of lophophore..." (Moore, Lalicker, and Fisher, 1952, Invertebrate Fossils, p. 209).
breccia	conglomerate composed of angular to subangular fragments, generally arranged in haphazard fashion.
calcarenite	limestone in which the clastic component exclusive of fossils is composed predominantly in a volumetric sense of limestone fragments greater than 1/16 mm. but less than 2 mm. long in apparent maximum dimension (refer to Table 15).
calcareous	referred to rock composed predominantly of dolomite or noncarbonate minerals that effervesces on a fresh broken surface with application of cold, dilute hydrochloric aci
calcilutite	limestone composed predominantly, exclus

	of sparry calcite crystals filling what presumably were at one time voids in the sediment or rock, of grains or crystals smaller than 1/256 mm. It is generally difficult to determine whether limestone wholly of calcilutite texture is clastic or chemical in origin.
alcirudite	limestone in which the clastic component exclusive of fossils is composed predominantly in a volumetric sense of limestone fragments greater than 2 mm. long in apparent maximum dimension (refer to Table 15).
alcisiltite	limestone in which the clastic component exclusive of fossils is composed predominantly in a volumetric sense of limestone fragments between 1/16 mm. and 1/256 mm. in size (refer to Table 15).
alcitic	referred to dolomite composed in part of megascopically visible calcite.
ement	"Authigenic chemical precipitate which infiltrates around grains and matrix" (Krynine, 1948, p. 138). Authigenic void filling is also referred to the textural element, cement. Cement is one of the three main textural elements of Krynine (1948, p. 137), grains, matrix and cement.
lastic	". . . particles or grains, either of detrital or of chemical origin, (which) have been rolled around and moved to and fro before coming to rest within the sediment." (Krynine, 1948, p. 137).
oarsely microcrystalline	petrographic textural term referring to limestone and dolomite or aggregates of crystals in which the majority of crystals are between 1/16 and 1/64 mm.
ostella (costa)	"Riblike thickening of shell extending generally from beak region to anterior or lateral margins." (Moore, Lalicker,

and Fisher, 1952, Invertebrate Fossils, p. 209.)

cranadium — "Central part of cephalon, . . ." (Moore, Lalicker, and Fisher, 1952, Invertebrate Fossils, p. 477.)

cryptogranular — megascopic textural term referred to lime stone which contains no megascopically visible clastic grains or readily detectable crystallinity (see also smoothly fracturing cryptogranular and roughly fracturing cryptogranular).

cryptozoon — a type of stromatolite "Characterized by relatively large subhemispherical, common cabbagelike heads composed of upwardly convex laminae 0.25 to 3 mm. thick" (Sand 1957, p. 38).

cycle — referred to the concept of a vertical series of changes in rocks that lead back to the starting point.

detrital — refers to "Material brought in as solid detritus from outside the basin of depositio . . . " (Krynine, 1948, p. 133.)

dolomite — sedimentary (and metamorphic) rock composed principally of the mineral dolomite and showing very little or no reaction on the fresh surface under cold dilute HCl.

dolomitic — referred to limestone composed in part of megascopically visible dolomite mineral in appreciable quantities (in practice probably more than 5 percent and less than 50 percent).

earlier dolomite — dolomite judged to have been formed by chemical precipitation of the mineral dolomite onto the basin floor or by essentially penecontemporaneous replacement of calcite and (or) aragonite sediment. Term suggested by P. D. Krynine in lectures at The Pennsylvania State University.

dgewise conglomerate	limestone conglomerate (calciridute) consisting in part of flattish fragments that usually show highly variable orientations with respect to bedding.
longate	length of grain between 1-1/2 and 3 times its thickness.
quant	"Length of grain is less than 1-1/2 times its width" (Krynine, 1948, p. 142).
quigranular	referred to rocks that are composed of grains that give the impression of being generally similar in size (qualitative).
uhedral	referred to crystals that are bounded by well-formed crystal faces in the plane of the thin section.
abric	interrelationship of rock particles in a rock as defined primarily by their orientation and packing.
inely microcrystalline	petrographic textural term referring to limestone and dolomite or aggregates of crystals in which the majority of crystals are between 1/64 and 1/256 mm.
formation	"A formation is a body of rock characterized by lithologic homogeneity; it is prevailingly but not necessarily tabular and is mappable at the earth's surface or traceable in the subsurface." (American Commission on Stratigraphic Nomenclature, 1961, Code of Stratigraphic Nomenclature, Article 6, Bull. Amer. Assoc. Petrol. Geol., Vol. 45, No. 5, p. 650.)
fragmental limestone	limestone composed in part of megascopically visible clastic grains or fragments.
fucoids	generically indeterminate fossil structures consisting of overlapping and anastomosing tubular and cylindrical forms. They are composed of dolomite where observed in Beekmantown rocks.

glabella	"Axial part of a cranadium, bounded by dorsal furrow at its front and sides" (Moore, Lalicker, and Fisher, 1952, Invertebrate Fossils, p. 477).
grains	one of the three main textural elements of Krynine (1948, p. 137), grains, matrix, and cement. Grains are the individual particles in a rock. "If particles are of different sizes, occurring in distinct order of magnitude, the term 'grains' is restrict to the larger particles." (Krynine, 1948, p. 137-138). See also definition of matrix.
group	"A group is the rock-stratigraphic unit next higher in rank than a formation; a group consists of two or more associated formations." (American Commission on Stratigraphic Nomenclature, 1961, Code of Stratigraphic Nomenclature, Article 9, Bull. Amer. Assoc. Petrol. Geol., Vol. 4 No. 5, p. 651.)
gymnosolen	a type of stromatolite. "The basic structu is a subcylindrical fingerlike process with transverse, upwardly convex internal laminae" (Sando, 1957, p. 36).
habit	the characteristic shape of a mineral.
impunctate	referred to brachiopod shells in which the layers are solid, lacking pores or punctae.
inverted asymmetrical cycle	an asymmetrical limestone-dolomite-limestone cycle in which the contact between the dolomite and the overlying limestone is transitional through a zone of calcite-dolomite mottling.
laminae	sedimentary stratum less than 1 cm. thick
later dolomite	dolomite judged to have been formed by late-or post-diagenetic replacement of limestone. Term suggested by P. D. Krynine in lecture at the Pennsylvania State University.

ime mud	loosely defined term sometimes referred to microcrystalline calcite component of limestone. It should more properly refer to the loose sediment.
imestone	sedimentary rock composed principally of the mineral calcite.
ithofacies	rock aspect that undergoes a demonstrable lateral gradation into a different rock aspect (see lithofacies type).
ithofacies type (and subtype)	group of strata that possesses a similar rock aspect or lithofacies and that undergoes a demonstrable lateral gradation into rocks of a different aspect.
natrix	one of the three main textural elements of Krynine (1948, p. 137), grains, matrix, and cement. "If particles are of different orders of magnitude, then the term 'matrix' is used for the smaller individual units which fill the interstices between the larger grains" (Krynine, 1948, p. 138).
nechanical limestone	". . . comprises limestone whose texture and structure is dominated by the effects of mechanical processes." (Sando, 1957, p. 33).
megacrystalline	referred to limestone and dolomite composed principally of megascopically visible crystals. Also referred to crystalline aggregates within the rock in which the crystal size generally exceeds 1/16 mm.
member	"A member is a part of a formation; it is not defined by specified shape or extent." (American Commission on Stratigraphic Nomenclature, 1961, Code of Stratigraphic Nomenclature, Article 7, Bull. Amer. Assoc. Petrol. Geol., Vol. 45, No. 5, p. 651).
microcrystalline	megascopic and microscopic textural term referred to limestone and dolomite composed

	principally of megascopically invisible crystals. Also referred to aggregates within the rock in which the crystal size is generally less than 1/16 mm.
micro-fractures	referred in this text to small, light-colored fracture-like veins of irregular form occurring chiefly in medium to very coarsely megacrystalline dolomite.
mottled	spotted or blotchy appearance of rock usually due to variations in composition and (or) texture.
operculum	in the gastropods, a horny or calcareous lid which fits over the aperture of a shell when the animal is inside.
paradoloarenitic	referred to dolomite that has a spotty appearance somewhat resembling an areniti texture in the hand specimen. In thin secti the "spots" may be "relict" grains, zoned crystals, or true clastic dolomite grains.
paradoloruditic	similar to paradoloarenitic but characterized by larger "spots."
pelmatozoan	subphylum of the Echinoderms which includ the attached or stem-bearing forms. (Moor, Lalicker, and Fisher, 1952, Invertebrate Fossils, p. 577.)
penecontemporaneous	referred to processes or features related to the time of deposition of the sediment or to the time in which the sediment is in contact with the water in the basin of deposition.
platy	length of grain more than 3 times its thickness.
pleural lobe	lateral part of the thorax and pygidium of trilobites.
pseudospondylium	shell deposit in dethyrial cavity of brachiopods which is similar to the

spondylium.

uartzose (arenaceous)	referred to limestone or dolomite that contains megascopically visible sand grains of quartz.
ecrystallized limestone	referred to a limestone in which original texture has been partially or wholly obliterated by recrystallization during tectonic flowage; such a limestone usually possesses a poorly defined cleavage.
elict texture	referred to features found in certain Beekmantown dolomites that are believed to indicate the existence of a former texture which was incompletely obliterated, presumably by dolomitization.
ock type (and subtype)	rock that possesses a similar composition, texture, and in the case of rock subtype a similar sedimentary structure or lack of structure.
oughly fracturing ryptogranular	megascopic textural term referred to cryptogranular limestone that breaks with a finely irregular or silty-looking surface.
rounded	"All edges (of a grain) are smooth" (Krynine, 1948, p. 142.)
roundness	grain shape as defined by degree of rounding of grain edges (see also rounded, subrounded, subangular, angular).
siliceous limestone (dolomite)	rarely used for limestone or dolomite with a megascopically unidentifiable silicate component which is usually quartz and feldspar silt or chert and occurs in irregular bands and laminae.
silty-argillaceous	referred to limestone with irregular laminae and streaks of detrital clay- and silt-sized silicate minerals; referred also to structures themselves.
silty	silt bearing

siphuncle	in cephalopods the tube leading from living chamber to protoconch, piercing septa near the middle.
smoothly fracturing cryptogranular	megascopic textural term referred to crypto granular limestone that breaks with a smoot usually conchoidal surface that lacks a silty appearance.
sparry calcite	textural variety of calcite characterized by relatively large, clear crystals; found as cement, void filling, and as recrystallized shell material.
sphericity	grain shape as defined by the ratio between length and thickness (see also equant, elongate, platy).
stromatolite	peculiarly laminated structures of variable morphology thought to be the work of algae (see also cryptozoon and gymnosolen).
subangular	"One-third of the edges (of a grain) are smooth" (Krynine, 1948, p. 142).
subhedral	referred to crystals that are partially bounded by well-formed crystal faces in the plane of the thin section.
submicrocrystalline	microscopic textural term referred to limestone and dolomite composed principally of crystals smaller than 1/256 mm.
subrounded	"Two-thirds of the edges (of a grain) are smooth" (Krynine, 1948, p. 142).
sulcus	"Major rounded depression of (brachiopod) shell along longitudinal mid-line affecting both outer and inner surfaces; generally on pedicle valve" (Moore, Lalicker, and Fisher, 1952, Invertebrate Fossils, p. 210).
symmetrical cycle	a limestone-dolomite-limestone cycle in which either both dolomite contacts are transitional through zones of calcite-dolomite mottling or both are sharp and unmottle

:xture	"Geometrical aspects of the component particles of a rock, including size, shape, and arrangement" (Pettijohn, F.S., Sedimentary Rocks, p. 8, 1949).
mbilicus	"Central cavity of a (gastropod) shell formed by walls on inner sides of whorls; . . ." (Moore, Lalicker, and Fisher, 1952, Invertebrate Fossils, p. 285).
pright asymmetrical cycle	an asymmetrical limestone-dolomite-limestone cycle in which the contact between the dolomite and the underlying limestone is transitional through a zone of calcite-dolomite mottling.